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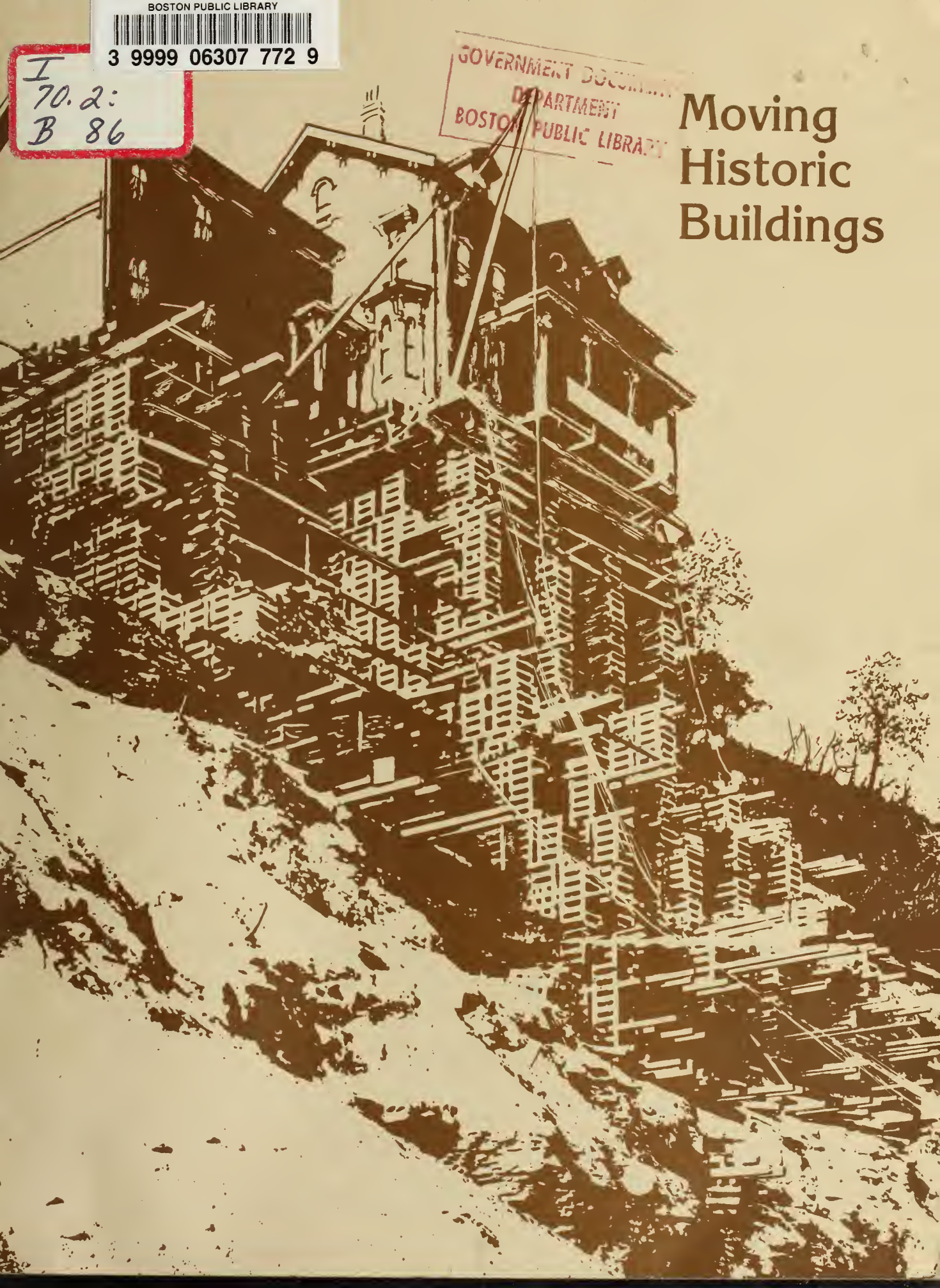
Moving Historic Buildings



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Moving Historic Buildings

John Obed Curtis

U.S. Department of the Interior
Heritage Conservation and Recreation Service
Technical Preservation Services Division
Washington, D.C. 1979

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, parks and recreation areas, and to insure the wise use of all these resources. The Department also has major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

The Heritage Conservation and Recreation Service, a non-land managing agency within the Department, is responsible for assuring the identification, protection, and beneficial use of our important cultural, natural, and recreational resources. The Service offers grant assistance, technical information, and guidance to those in the public and private sectors involved in conservation or recreation projects.

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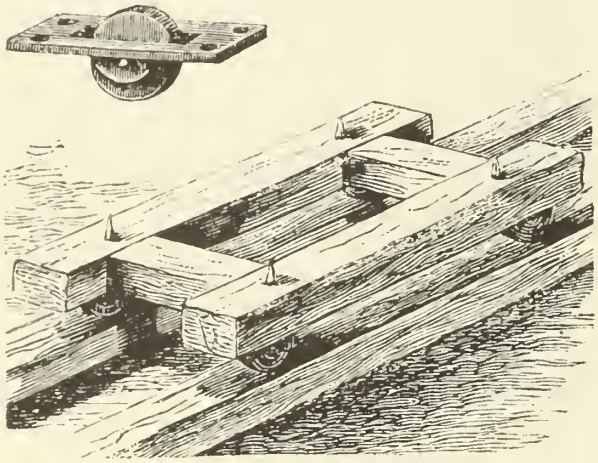

Fig. 1.—CARRIAGE FOR MOVING HOUSES.

Fig. 2.—HOUSE RAISED BY SCREWS.

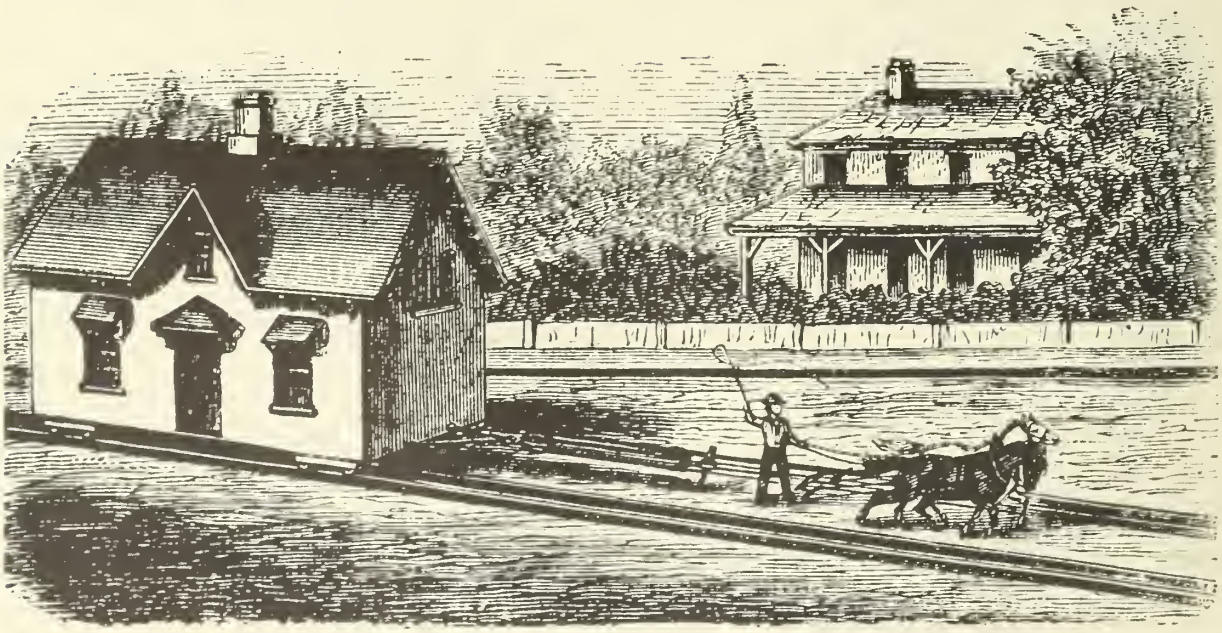

Fig. 3.—THE HOUSE ON ITS TRAVELS.

—American Agriculturalist, volume 32, November 1873.

Foreword

Moving a historic building is sometimes the only way to save it from demolition, but such an action should be undertaken only as a last resort when all other preservation options have been exhausted. When a historic building has been moved, it loses its integrity of setting and its "sense of place and time"—important aspects of the historic character of a building and its environment. All too often, however, historic and architecturally significant structures are subjected to intense economic or planning pressures from which there are no reasonable alternatives except relocation. It is a procedure which requires considerable skill and experience. Despite the effort and risk involved, Americans have been moving buildings successfully since the early 18th century.

This publication was developed by the Technical Preservation Services Division, Office of Archeology and Historic Preservation, Heritage Conservation and Recreation Service, as part of a Preservation Handbook series for use by architects, administrators, and government officials at all levels concerned with the preservation and maintenance of cultural resources. John Obed Curtis, Director, Curatorial Department, Old Sturbridge Village, wrote the first section of this report under contract with this office. The supplementary case study on the relocation of the Gruber Wagon Works was written by Charles A. Parrott, III, formerly of John Milner Associates, now with Technical Preservation Services Division, and is based on his paper presented at the 1977 Annual Conference of the Society for Industrial Archeology.

Several staff members made substantial contributions toward the publication of this report: Laurie Robin Hammel, Architectural Historian, who developed the initial subject outline, worked with the author to develop the manuscript and edited the first draft; Marsha Glenn, Summer Intern, who located much of the documentary material on the history of house moving; and Anne E. Grimmer, Architectural Historian, who edited the revised manuscript, the case study, and the illustrative materials into the present published form. The final draft was edited by Deborah Cooney, Writer/Editor, Technical Preservation Services Division.

Other individuals that made helpful contributions to this publication include: John Ingle, formerly with the Corps of Engineers, Philadelphia; Tim Turner, Southwest/Plains Office, National Trust for Historic Preservation; John Milner, John Milner Associates; Peter M. Coope, Mystic Seaport, Inc.; and James H. Mundy, formerly Maine State Historic Preservation Officer.

Comments and suggestions regarding this publication are encouraged, and should be sent to Technical Preservation Services Division, Heritage Conservation and Recreation Service, U.S. Department of the Interior, Washington, D.C. 20243.

Lee H. Nelson, AIA
Preservation Handbook Editor,
and
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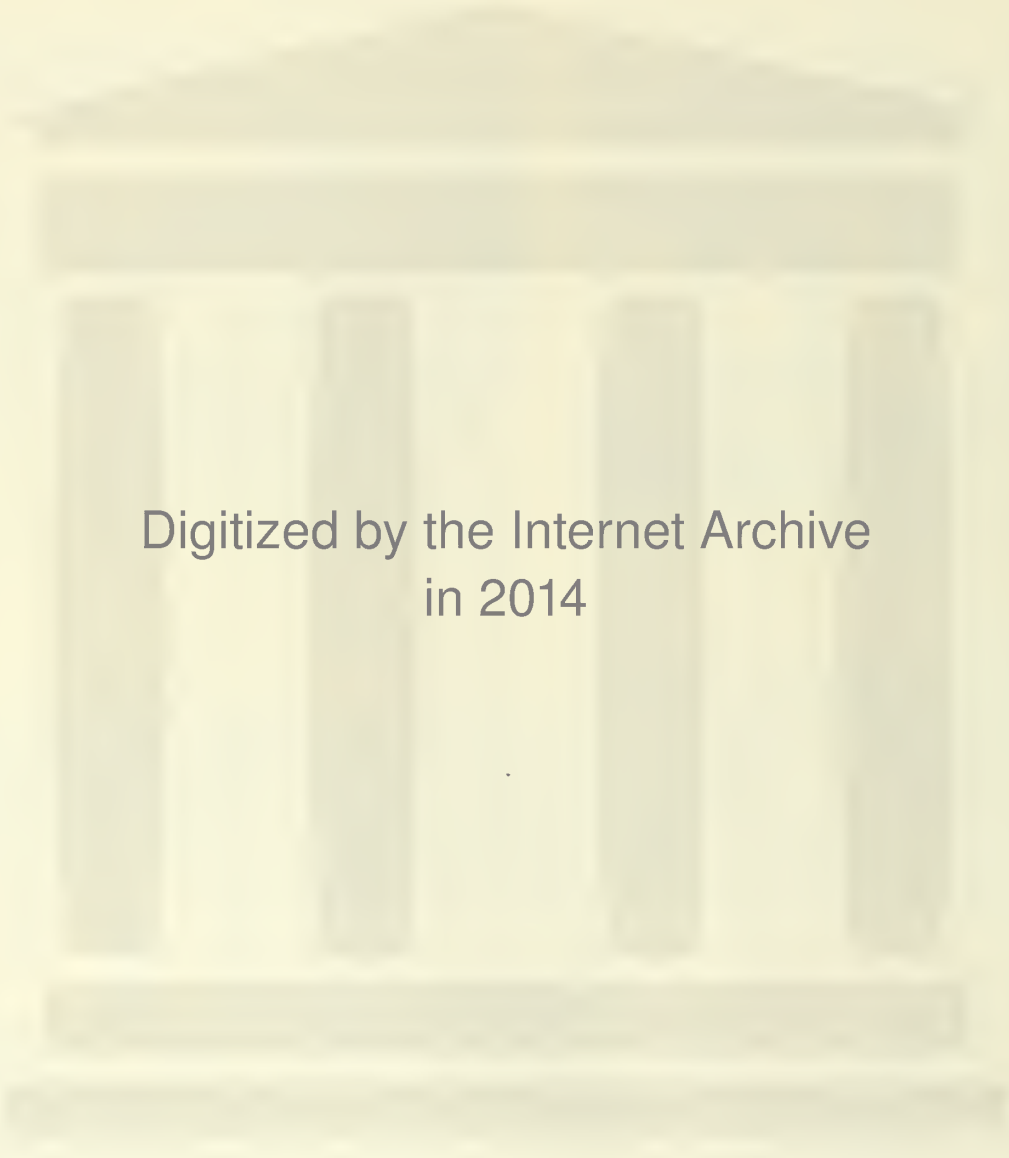
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Introduction

Moving a historic building is a delicate operation; it should not be undertaken until all other possible ways to save a structure from demolition have been investigated. This report has been prepared to serve as a guide for just such a situation. Its aim is to explain the precautions to take, and to suggest procedures to follow during the relocation process that will cause the least damage to the character and historic fabric of the building.

The subject of building relocation, or "house moving" as it is more popularly termed, is a matter often viewed as a remarkable feat, possible only through the skillful application of the most modern technology available. In actuality, the relocation of buildings has been a fairly common occurrence in the United States since the late 18th century (figure 1). The fact that it was frequently easier to move a building than to construct a new one doubtless

Figure 1. Moving a building in Philadelphia in 1799

One of the earliest illustrations to be found of house moving in America is this 1799 engraving by William Birch and Son, which illustrates a small frame building being moved by teams of horses.

Note the use of cross bracing to provide added support for the structure during its move on wooden wheels. In the background is the Walnut Street jail, designed by master builder/architect Robert Smith in 1773–74, and sited directly opposite the State House Yard. This view is one of twenty-eight engravings included in "The City of Philadelphia in the State of Pennsylvania, North America as it Appeared in the Year 1800" published by William Birch on December 31, 1800. [Photograph: Collection of the Library of Congress]

has played an important part in the tradition of house moving everywhere. National or community pride has also played a role in decisions to move important buildings and even whole towns.

In recent years, one of the most common reasons for moving a building has been the construction or widening of a street or highway (figures 2 and 3). In the past, other circumstances which have necessitated a building relocation include: moving a county seat, retreating from a rising tideline, the installation or widening of tracks, and the discovery of a valuable vein of iron ore or coal beneath an exising town. A majority of the more recent building relocation projects in the United States have been undertaken as alternative to demolition. A secondary factor has been economic—it may have been cheaper to move an existing structure than to construct a new one. Although most of the buildings which have been relocated in the last two centuries probably were not thought historically significant in their own time, now the preservation of the architectural and historical qualities of old buildings is the primary reason for moving them. Relocation may be the only way to save these now historic structures.

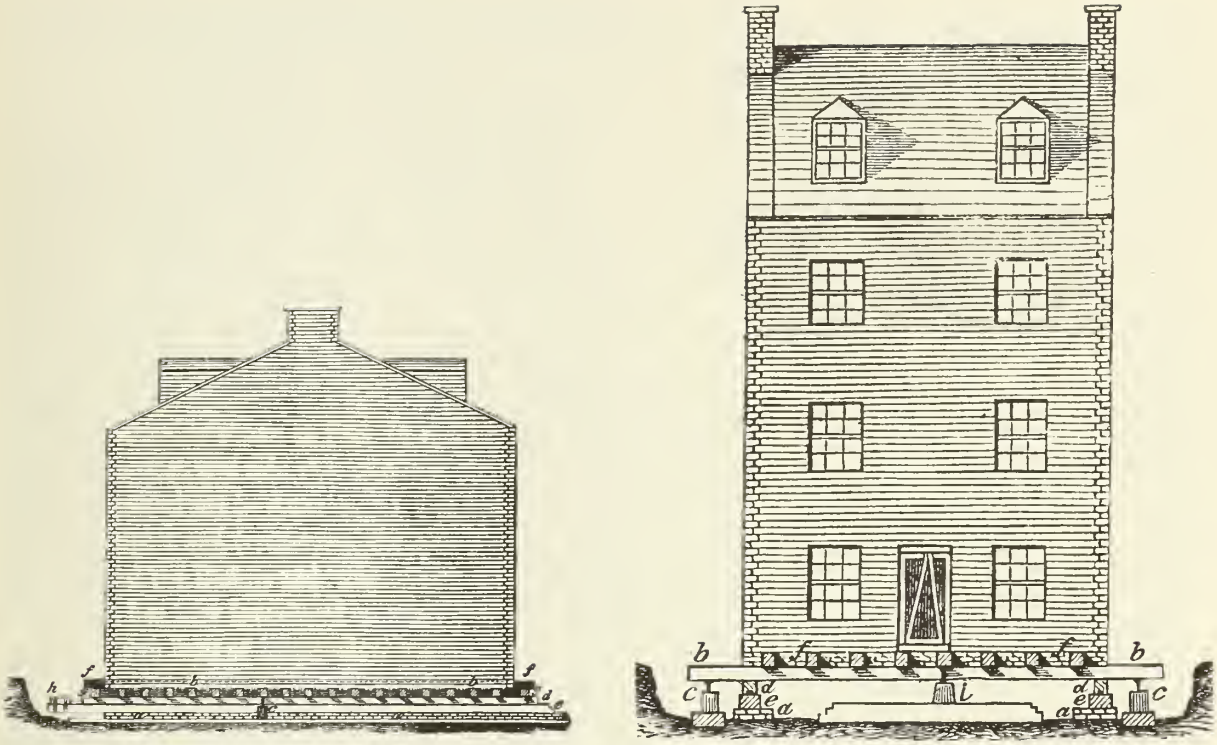
Moving a historic structure, whether intact or in a totally or partially dismantled state, unavoidably destroys some of the historic fabric and lessens the historic integrity of the building. Some building types lend themselves to moving better than others. A small frame structure, which can be moved intact, is unquestionably easier to relocate, with less disturbance to its integrity, than a large multi-storied, masonry building. Often richly ornamented with plaster cornices, moldings, and elaborately carved woodwork, this type of building may require disassembly in order to be moved.

Often the original site and its relationship to the historic structure is as important as the building itself. A relocated building, even if placed on a terrain similar to where it stood previously, will seldom have the same aesthetic relationship to its new site. Thus the selection of a new site, appropriate for the building, plays an important role in the success of the relocation project.

When the decision is made to move a historic structure, careful consideration must be given to determining what aspect of the structure contributes most toward qualifying it as worthy of preservation. Factors to be evaluated might include: the uniqueness of the building type, its craftsmanship, some outstanding decorative interior painting, an unusual structural system, the nature of the building fabric itself, or even the relationship of the building to its setting. The method selected for the building relocation process should reflect the importance of saving just such a significant feature.

If it is essential to preserve a unique or obsolete method of timber framing, for example, it is important not to sever the structure in a way that will be conspicuous after it has been reassembled. Even though such a method is often tedious, time consuming, and may require careful dismantling of the individual framing members, the result will be worth the effort. This procedure was used in the disassembly of the Gruber Wagon Works (see the case study, this report), necessitated by the exposed interior framing of that structure.

Although the art of house moving is neither a new nor technically complex invention of the 20th century, engineering a building move must be done with care to ensure the safe and successful relocation of a historic structure. It cannot be overemphasized that such buildings should be moved only as a last resort, and if they are moved, precautions must be taken so that the historic significance of the building is not destroyed in the process. If those who are about to embark upon such a project follow the advice given in the text that follows, their relocation project should be greatly facilitated, with the result that the structure retains its architectural integrity, and is harmoniously integrated with its new site.



Figures 2–3: Moving a brick house In New York In the 1830s

When David Stevenson, a civil engineer from Scotland, published his "Sketch of the Civil Engineering of North America" in 1838 (an account of his three-month-long travels through the United States and Canada), his fascination with the phenomenon of house moving led him to include an entire chapter on this subject in his book.

> In consequence of the great value of labour, the Americans adopt, with a view to economy, many mechanical expedients, which, in the eyes of British engineers, seem very extraordinary. Perhaps the most curious of these, is the operation of moving houses, which is often practised in New York.

With the aid of the sketches included here, Mr. Stevenson proceeded to explain to his readers the manner in which a four story brick row house, 50 feet long by 25 feet wide, at 130 Chatham Street in New York City was moved back 14 feet 6 inches from the newly widened street. The house, supported by logs on beams labeled (b), (f) and (g), was moved by working screw-jacks (h) attached horizontally to beams labeled (e), pushing forward the upper beams (d) which slide on the lower beams (e) which serve as a sort of track on which the house moves. These beams (d and e) are well greased, and a groove on the upper beams and corresponding "feather" (projection or tongue) on the surface of the lower beam keeps the building moving in the right direction. Because the lower beams (e) form the "path," they must be extended resting on a firm foundation accordingly until the structure reaches its new foundation. If the building is to be moved farther than the length of the horizontal screw-jacks (about 2 feet), the screw-jacks must be unfastened, then reaffixed to the beam (e), and the same process repeated.

Mr. Stevenson was particularly impressed by the fact that the building's occupants had not bothered to move their furniture before the move, and "was astonished to find" they had left pictures and mirrors hanging on the walls. Although the actual time spent moving the house 14 feet 6 inches was only 7 hours, the completion of the project took a total of about 5 weeks. [Illustrated in David Stevenson, "Sketch of the Civil Engineering of North America;" London, John Weale, Architectural Library, 1838]

Figure 4: Hotel Pelham, Boston

Probably the earliest instance of the relocation of a large masonry structure took place in Boston in 1869, when the seven-story Hotel Pelham was moved back to permit the widening of Boyleston Street. Constructed of freestone and brick, the building covered 5,800 square feet and its weight was estimated at 5,000 tons. According to a contemporary report in the **Journal of the Franklin Institute**, there was some question about the feasibility of such a move, but experts were consulted who declared it possible, as well as less expensive than the alternative of cutting off a portion of the front to allow for the widened street. The building was moved a total of 13 feet 10 inches at a rate of about 1 inch every 5 minutes. Through an elaborate system, incorporating a combination of 904 rollers and 72 screws, the structure was pushed along iron rails. The complete removal process took approximately 3 months, during which time the first floor businesses, and several of the apartment tenants remained in residence, with plumbing and gas services kept in continuous operation through the use of flexible tubes. [Photograph: Courtesy of the Boston Public Library Print Department]

Figure 5: Courthouse, Box Butte County, Nebraska

In 1889, when the Burlington Railroad was cut through Box Butte County, it bypassed the county seat of Nonpariel, passing instead through two neighboring towns, Alliance and Hemingford. Clearly, the county seat would have to be changed to one of the towns on the railroad line. An election was held to determine whether Alliance or Hemingford would have the honor of becoming the new county seat. Through some questionable voting, Hemingford was selected and a new courthouse was erected there. Ten years later in 1899, the matter was still unresolved for many residents of Alliance, and the question was put to the vote again. This time Alliance won, and the county commissioners were faced with the quandry of what should be done about a courthouse for Alliance.

Rather than building a new courthouse, the county commissioners decided to purchase the 10-year old courthouse in Hemingford and move it to Alliance, all for the amount of $1500. Ironically, the courthouse was moved to its new location by the same railroad that caused the relocation of the county seat in the first place. The structure, which measured approximately 45 feet by 54 feet by 40 feet high, weighing 95 tons, was mounted on nine pairs of railroad car "trucks" and placed between four large, loaded coal cars which served as anchors. The courthouse was pulled by a locomotive to its new home 9 miles away. Accompanied by a train crew of 75, which facilitated the train's progress by widening cuts where necessary, the train proceeded at 10 miles per hour. The move elicited considerable attention, and the event was publicized with commemorative plates and silver spoons with the picture and the date of the move, July 3, 1899. [Photograph: Courtesy of the Alliance Knight Museum]

Figure 6: Captain Samuel Brown's Mansion, Brown's Station, Pennsylvania

Buildings can be moved vertically, up or down a steep hillside, as well as horizontally, a fact well illustrated by this photograph of the relocation of the Captain Samuel Brown mansion at Brown's Station, now part of Pittsburgh. Originally constructed in 1868 on the edge of the Monongahela River, the house had to be moved in 1903 because of the construction of the Baltimore and Ohio railroad tracks. By this time the house was in the possession of James Ward, Jr., a relative of the original owner. Since he owned a large section of orchard land at the top of the bluff 160 feet above the house, Mr. Ward decided to lift the building to the higher area.

The feat of moving the house, 85 feet by 40 feet and weighing about 800 tons, was planned and executed by the John Eichleay, Jr. Company, an engineering firm in Pittsburgh. The firm supplied information for an article about the move to the **Scientific American.** In order to carry out this move, it was first necessary to insert 8 large timbers, 12 inches by 16 inches by 85 feet in length, beneath the building, and then to lay approximately 200 steel needle beams 7 inches in diameter between the timbers and the building structure. While this work was being performed, the side of the cliff was "stepped out" into four vertically placed benches about 30 feet apart on which the house could "rest" during its journey up the hill.

The building was then raised a small amount at a time using hand jacks, so that eight walls of timber cribwork could be built up beneath it. This cribwork was strengthened by 8-inch by 8-inch waling pieces, and it was sway-braced by ½ inch chains with turnbuckles. When the building had been raised 30 feet, it was pulled onto the first bench using two winches located at the top of the cliff. Each winch was driven by two horses, using 2-inch line with four-part blocks. This operation was repeated four more times until the house had been placed on its new site, 200 feet back from its former site and 160 feet above it. The move required over 20,000 wooden beams and timbers, which had to be transported to the site in twenty railroad cars. Because the $40,000 cost of moving the Brown mansion considerably exceeded that of its original construction, it is believed that the move was undertaken primarily out of a desire to preserve a family inheritance. After such great effort, it is sad to relate that the structure was totally destroyed by fire 10 years later, in 1913.
[Photograph: Courtesy of the Carnegie Library of Pittsburgh]

Figures 7–8: Hibbing, Minnesota

Discovery of a large vein of iron ore beneath approximately one-third of the town of Hibbing in 1919, led to possibly the most extensive building relocation project undertaken in the United States at that time. The structures within the sixteen-block area covering this vein of iron ore were gradually moved over a period of about three years to a new area on the outskirts of town. The immense scale of the project involved a great deal of manual labor and required considerable skill, as well as the use of numerous types of moving equipment: primarily steam locomotive tractors with traction belts and jacks, horse teams and wagons, and heavy trucks and logs.

These two photographs suggest the variety of buildings moved during this relocation project—including houses, a hotel, a church, the city market, clubs and many other commercial and private structures. Some buildings were constructed of brick and others of wood. The size of this project prefigured a similar project undertaken half a century later in Most, Czechoslovakia, in order to reach a rich vein of coal lying below the surface of the village. (See figures 12–17 for an illustrated description of that relocation project.) [Photographs: Courtesy of the Minnesota Historical Society]

Figure 9: Perry Mansion, Bay Ridge, New York

In 1923 when the Perry Estate, the last remaining large tract in the Bay Ridge section of Brooklyn overlooking New York Bay, was to be broken up into smaller parcels of land, the 60-year old Perry Mansion was moved from its original and somewhat elevated location to another slightly lower site on the opposite side of a busy street. To further complicate the move, the roadway had to be kept open for traffic. The house was first jacked up and placed on cribbing, which was then extended to the edge of the roadway, and the house was moved on rollers to the end of the cribbing 28 feet above the street. Because the opposite bank was lower, enough of the cribbing under the house was removed to bring the house down to a height equal to that of the other bank. Cribbing was then built out from the other side, leaving a space large enough to allow the passage of cars. This opening was bridged with long heavy timbers, and the house was pulled across, where it was resituated 200 feet from its original location.

This view shows the Perry Mansion on its cribbing at the edge of the hill, prior to erection of the bridging across the street. This photograph was featured in the March 1, 1923 "Brooklyn Daily Eagle " [Photograph: Courtesy of the Brooklyn Public Library, Brooklyn Collection]

Figures 10–11: "Lucy," The Margate Elephant

"Lucy," the Margate Elephant is probably one of the most unusual structures known to have been moved in the United States. Built in 1881 at Margate City, New Jersey, as a real-estate promotion gimmick (her design was patented in 1882), "Lucy" epitomizes the type of "architectural folly" popular in the late 19th century. The structure stands 58 feet high, 72 feet long and 28 feet wide. Lucy's shape was achieved by applying curved, multifaceted wood ribs over the box frame. These ribs were sheathed with thousands of yellow pine boards, many cut in unusual and irregular shapes, and finally the entire structure was covered with small sheets (approximately 2 feet by 2 feet) of heavy terne plate, totalling 12,000 square feet.

Over the years the interior of the structure, reached by spiral stairs located in the rear legs, served as a summer cottage, a tavern, and a tourist attraction. "Lucy" was listed on the New Jersey Register of Historic Landmarks in 1966, although unused and in a poor state of preservation. Eventually "Lucy's" plight was brought to the attention of local citizens who formed a "Save Lucy Committee." "Lucy" was donated to the Committee, which was able to raise enough money to move her to a city-owned site only two blocks from the original during the summer of 1970.

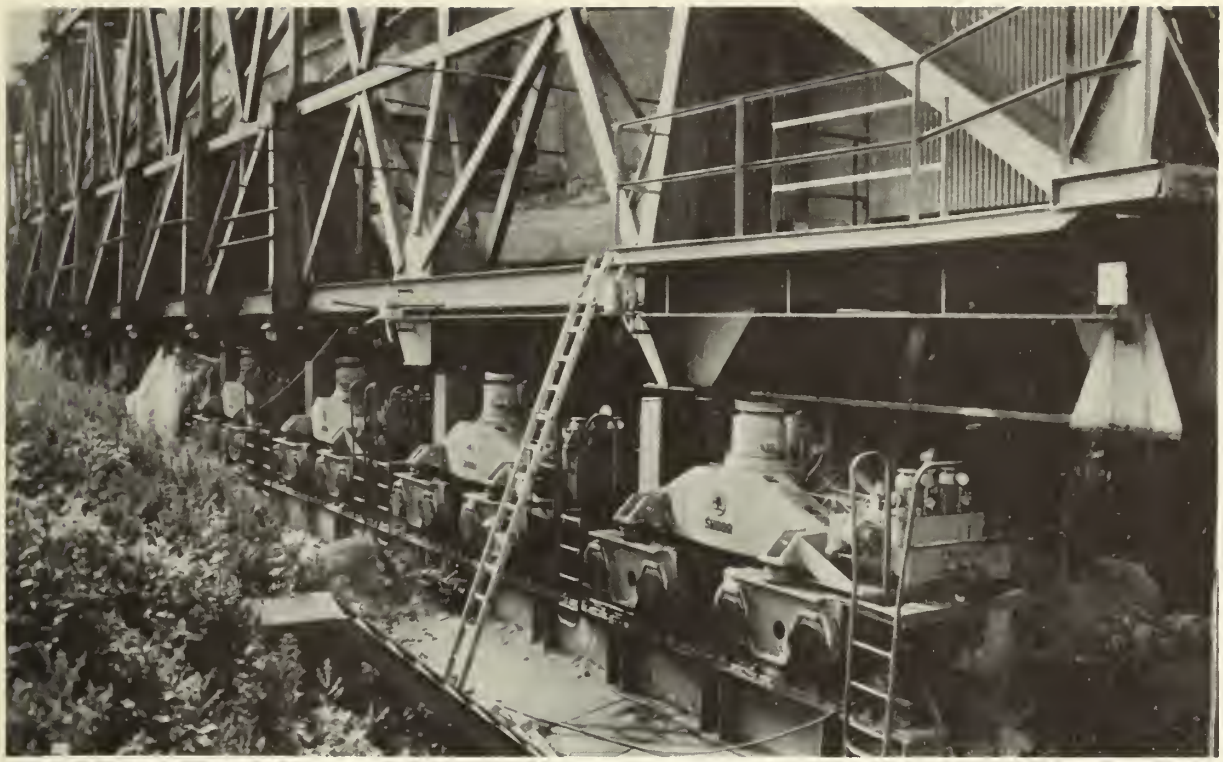
In order to carry out the move, "Lucy" was raised from her location by hydraulic jacks and wooden cribbing; she was placed on a heavy steel framework carriage and supported by three separate sets of wheels. Resting on this carriage, "Lucy" was towed to her new site and lowered onto her new foundation. The foundation consisted of five concrete pads for the four legs and trunk, each 10 feet square by 3 feet deep, which were set on 26 foot long wooden pilings driven into the sand.

Following the move, "Lucy" was listed in the National Register of Historic Places, and thus was able to receive financial assistance from the Department of Housing and Urban Development and a grant from the National Park Service for restoration. The restored structure is now used as the Museum of New Jersey Shore History. [Photographs: Courtesy of John Milner Assoc.]

Figures 12–17: Church of The Virgin Mary, Most, Czechoslovakia

The discovery of an 87-million ton deposit of high quality coal beneath a city led to one of the most impressive and technically complex relocation projects ever undertaken. This four year relocation during the mid-1970s involved moving the historic section of Most, Czechoslovakia, to a new site, one-half mile away. The relocation of the 14th-century Church of the Virgin Mary provided the most dramatic sight. In order to ensure the safety of this architecturally significant church, Czechoslovakian engineers at Inova, a research and development organization in Prague, developed an intricate monitoring and control system with the assistance of Hewlett-Packard electronic calculators. It is interesting to note that the Czechoslovakian government spent approximately $20 million on this relocation project.

Figure 12: The first step in the moving process was to remove the later addition of a tower (not seen here). Then a steel girdle was constructed, approximately 197 feet long by 97 feet wide by 103 feet high, to encircle the structure. [Photograph from a slide by Jack E. Boucher, 1975]



Figures 13–14: The weight of the church and its steel supportive superstructure, together totaling 10,560 tons, was raised to allow the emplacement of more than 50 trolleys (figure 13) which carried the church over four sets of train tracks to its new site (figure 14). [Figure 13 from a slide by Jack E. Boucher, 1975. Figure 14 photograph by W. Preiss, Dresden, 1975, courtesy of Jack E. Boucher]

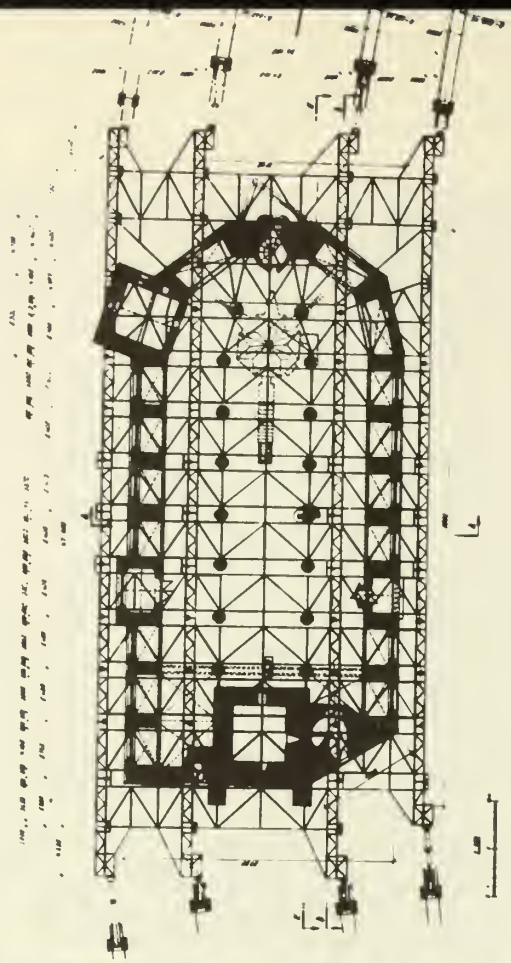


Figure 15: This diagram illustrates the detailed system of exterior and interior bracing used to support the church, and the route it was to follow during the move. [Photograph: by W. Preiss, Dresden, 1975, Courtesy of Jack E. Boucher]

Figure 16: Each of the sixteen interior masonry piers separating the nave from the aisles was girdled with a steel support extending from the floor to the springing of the vaults.

The steel supports encasing the piers were then connected longitudinally by steel beams which were in turn supported by the addition of vertical steel beams between every two piers. This same bracing system was further reinforced by a similar arrangement of tie beams extending across the width of the church. Such thorough supportive measures were necessary to ensure that the interior angles of the church remained constant during the move. Even though the church was moved very slowly (approximately 1 inch per minute), a specially designed hydroelectric stabilization system was developed using two Hewlett-Packard 9821 calculators which continuously monitored any possible shifting in the church structure. This system was linked to sensors attached to the trolleys, and any change in the alignment of the structure, as minute as 1/25 of an inch, was equalized with the assistance of the computers. [Photograph: W. Preiss, Dresden, 1973, courtesy of Jack E. Boucher]

Figure 17: This photograph further illustrates the elaborate measures taken to stabilize the structure. The groins of the intricately detailed lierne vaulting were braced to cushion them from possible shocks during moving, and to make certain that this area of the church was tied into the monitoring system. [Photograph from a slide by Jack E. Boucher, 1975]

Community and Federal Involvement

Prior to beginning a building move, and indeed, even before acquisition, be certain that the structure is free from legal encumbrances, and that its removal from a community will not generate ill will toward the agency or individual initiating the move. Written authority should be obtained, if necessary, from the local historical commission; in some areas, the consent of the comparable state level officials may also be required. If the structure in question holds a prominent position in the middle of a historic district or a street that presents a unified appearance, its removal might leave an awkward gap or destroy the rhythmic harmony of the street or neighborhood. In this kind of situation, a design solution agreeable to both sides will have to be worked out between the owner of the property and the local residents or historical commission. However, in most cases, this is not a problem: if relocation is the only way to save the building, the site of the building is obviously required for some other purpose. In this instance, it is unlikely the local residents or historical commission will object to removal of the threatened structure.

Except for concern over the actual removal of the building itself, the greatest degree of community interest may be with site clearance and reclamation subsequent to the removal of the structure. Occasionally, fees for the use of town equipment and personnel are involved at this phase of the project if such assistance is utilized in cleanup and site stabilization.

Relocating Properties Listed in the National Register

Properties listed in the National Register of Historic Places must be moved in accordance with the following regulations—Part 60, Chapter 1, Title 36 of the Code of Federal Regulations—if the property is to remain listed.

(1) Properties listed in the National Register should be moved only when there is no feasible alternative for preservation. When a property is moved, every effort should be made to reestablish its historic orientation, immediate setting, and general environment.

(2) If it is proposed that a structure listed in the National Register be moved and the State or Federal agency wishes the property to remain in the National Register during and after the move, the State or Federal agency must submit documentation prior to the move which should discuss:

(i) The reasons for the move;

(ii) The effect on the property's historical integrity; and

(iii) The new setting and general environment of the proposed site, including evidence that the proposed site does not possess historical significance that would be adversely affected by the intrusion of the structure. In addition, photographs showing the proposed location must be sent along with the documentation. Any such proposal submitted by a State must be approved by the State review board and will continue to follow normal review procedures.

(3) If the National Register approves the proposal, the property will remain on the National Register during and after the move unless the integrity of the property is, in some unforeseen manner, destroyed. If the National Register does not approve the proposal, the property will be automatically deleted from the National Register when moved. If the State or Federal agency has proof that previously unrecognized significance exists, or has accrued, the State or Federal agency may resubmit a nomination for the property as outlined below.

(4) In the event that a structure is moved, deletion from the National Register will be automatic unless the above procedures are followed prior to the move. If the property has already been moved, it is the State or Federal agency's responsibility to notify the National Register. Assuming that the State or Federal agency wishes to have the structure reentered in the National Register, it must be nominated again on new forms which should discuss:

(i) The reasons for the move;

(ii) The effect on the property's historical integrity, and

(iii) The new setting and general environment, including evidence that the new site does not possess historical significance that would be adversely affected by the intrusion of the site.
In addition, new photographs showing the structure at its new location must be sent along with the revised nomination. Any such nomination submitted by a State must be approved by the State review board.

(5) Properties moved [as a result of a Federal, federally assisted, or federally licensed project] in a manner consistent with the comments of the Advisory Council on Historic Preservation, in accord with its procedures (36 CFR Part 800), are granted an exception to § 60.16(b). Moving of properties in accord with the Advisory Council's procedures should be dealt with individually in each memorandum of agreement.

Tax Reform Act

Property owners also should be aware that under section 2124 of the Tax Reform Act of 1976, a historic structure which has been moved, as well as the land on which the historic structure was previously situated, may not be eligible to receive certain tax benefits, and indeed may be subject to tax provisions. Since this decision will be made on an individual or case-by-case basis, it is important that owners of historically significant structures (listed in or eligible for listing in the National Register), consult with the Office of Archeology and Historic Preservation, Heritage Conservation and Recreation Service, before they embark upon a relocation project which might render the property ineligible to receive tax benefits for rehabilitation.

Selecting a Moving Contractor

Early in the project, it will be necessary to locate a professional building mover to relocate the structure. The choices may be limited, depending on the location and complexity of the project. No individuals and few institutions have either the necessary equipment or sufficiently trained personnel to undertake the moving of a building. This generally holds true even if the owner or agency's staff artisans do much of the preliminary preparation for an "intact" move or completely disassemble the structure. Neither party is likely to have vans or low-bed trailers available to transport the building components.

If possible, employ a firm with experience in moving historic structures. If none is available, try to locate a firm which shows an interest in and some sensitivity to historic materials and understands the appropriate techniques. It would be advisable to work closely with the movers, no matter what their level of expertise.

In some unusual instances it may be necessary to contract with two building moving firms if one does not have sufficient equipment for the job. Sometimes it is possible for a contractor to rent additional equipment. Screw and hydraulic jacks, cribbing and bridging timbers, wheeled dollies, cranes, tractors, and trailers are the primary tools of the building moving contractor. During recent years even helicopters (figure 18), ships, and barges (figure 19) have been utilized in building relocation, while steam engines, train cars (see figures 5, 7, 8) and teams of oxen were commonly employed for such projects in earlier times.

Adequate insurance coverage must be provided for all phases of the operation, and it is the responsibility of the contractor to provide the building owner with certificates of proof that he is covered against both public liability and workmen's compensation. Public liability coverage may vary, but $100,000 to $300,000 for individual injury, and from $300,000 to $500,000 for a group injury are reasonable limits. The contractor should also maintain at least $50,000 property damage protection as well as the amount of workmen's compensation

Figure 18: Moving by helicopter

Illustrated here is a less traditional method of moving a small building. When Mystic Seaport decided to acquire this little "Halfway House" in 1968, it was apparent that its location on sand dunes, halfway between two life-saving stations on Cape Cod, made it quite inaccessible and almost impossible to remove using conventional land or sea vehicles. With the help of the U.S. Marine Corps, the Halfway House was airlifted onto a flat-bed trailer which had been placed in a nearby visitor parking lot. The process was complicated by the blowing sand raised by the rotating helicopter blades, and by the unexpected weight of the Halfway House which caused a loss of engine power, endangering the helicopter and operator. Only after the excess fuel was drained from the helicopter could the building be lifted safely and removed to the trailer, on which it was transported to its new location at Mystic Seaport. [Photograph: Courtesy of Mystic Seaport, Inc.]

specified by the state or states within which the firm is operating. Workmen's compnsation is regulated by state statute and, if a contractor does not carry it, the owner may be held responsible for injuries to the contractor's employees. Additionally, it is advisable for the nongovernmental owner to carry comparable coverage, to back up that held by the contractor, against the possibility of a joint suit resulting from a serious accident. Unless the building is owned by a Federal or state agency, the owner should have replacement value insurance on the building. It is also the nongovernmental owner's responsibility to provide the contractor with a certificate demonstrating all risk coverage.

Figure 19: Moving by barge

Another means of transporting buildings to a new site is by barge. Not a new technique, this method is particularly effective for relocating structures on or nearby a navigable waterway, and has the added benefit of not tieing up ground traffic. When the pre-Revolutionary Buckingham House in Old Saybrook, Connecticut, was threatened with demolition by the construction of a new highway bridge across the Connecticut River in 1959, the structure was offered to Mystic Seaport.

In order to move the house, the main section, built in the second quarter of the 18th century, was separated from the kitchen addition in the rear. (Interestingly enough, the kitchen section was built in the 1690s and had been moved and attached to the main house in the 18th century.) The roofs of both sections were removed, and their openings covered as protection against the elements. Both were placed on a barge and shipped to Mystic Seaport, where the sections were reassembled and set on a new foundation and the house restored to its 18th-century appearance. [Photograph: Courtesy of Mystic Seaport, Inc.]

Specifications and Licenses

Specifications for moving a building naturally will vary from project to project. However, certain aspects of the work must be agreed upon, and both the owner's and the contractor's interests are best served if details are in writing. Responsibility for preliminary work, research, documentation, field studies and new site selection best lies with the owner, since the building moving contractors are unlikely to have staff skilled in these specialities. Similarly, the owner should arrange for and oversee archeological site work. See the chapter on documentation for a fuller discussion.

Certain permits and fees are necessary, and it is usually the responsibility of the moving contractor to obtain the proper documents and pay the fees. The contractor must have permits from the state for conveyance or travel of heavy equipment over the roads; these may include explicit stipulations about traffic tie-ups and road blockage. Permits may even designate the time of day and the months of the year during which the move can be made. In some states, the Department of Public Works is the licensing authority, although responsibility may vary from state to state. Certain states and counties require proof of prior notification to utility companies whose crews will be required to assist in raising or temporarily removing overhead wires. Depending upon differing state or utility company policies, there may be fees for the temporary relocation of wires, and provision for such costs should be written into the project specifications and budget. In instances where a structure will be moved through a grade crossing or railroad right-of-way, it will also be necessary to obtain permission and clearance from the railroad authorities. Each governmental entity through which the building moves can, conceivably, charge for permits, police assistance, and tree work.

The contractor should arrange for all requisite permits, licenses, and utility companies' services, plan the travel route together with the owner, provide certificates of insurance coverage, prove the ability to comply fully with all local and state safety regulations, and also provide all necessary equipment and vehicles unless otherwise agreed. Fumigation (if necessary) of disassembled components, since they will be transported in the contractor's vans, should also be part of the contractor's responsibilities. It is the obligation of the contractor to be aware of, and comply with, all state and local safety regulations covering wide-load transport including such things as flares, flags, signs, and warning vehicles.

The contractor should outline the period of time expected to complete the given project. The owner should be able, however, to exercise the prerogative of interrupting work at critical intervals to record architectural evidence vital to the accuracy of the planned restoration.

If the contractor is providing a "package" which includes a new foundation, then the contract should clearly define the architectural character of the new foundation, the finish grade at the new site and, if included in the total "package," provisions for grading or backfilling the original site after all data, archeological or otherwise, has been recovered from it. If the moving contractor does not have the personnel or capability to undertake the new foundation work, then the owner or agency should assume that responsibility. If the contractor is to be responsible for post-move work, the contract should also specify the nature of any and all replacement or restoration materials to be used in either repairing or reassembling the moved structure.

The basis for bidding the job should be the contractural considerations previously discussed. It may well become quite evident, however, that due to the relative scarcity of building-moving firms in some locales, the bid process becomes merely an ideal and the owner is fortunate, indeed, to find a single firm within reasonable distance equipped and competently staffed to handle the job.

Selecting the Best Procedure for the Move

Buildings can be moved in basically three conditions: intact, partially disassembled, or completely disassembled. The procedure adopted for the removal of a structure from its existing site is dependent upon several factors. One of the primary considerations is the physical condition of the building. Advanced structural decay of sills and sidewall frame elements may preclude moving a frame building intact. The construction material of the building is also a determining factor. Large masonry buildings, for example, are difficult to move intact over long distances. The size limitations posed by the selected travel route, such as narrow and winding roads, or height restrictions of highway bridges or underpasses are also essential considerations. Regulations for loads traveled over roads in some parts of the country limit overall height to a maximum of 18 feet. It is therefore essential to ascertain height, weight, seasonal regulations and restrictions from authorities in the particular locale well in advance of the actual move. Proximity of adjacent structures and the nature of the immediate topography are also deciding factors in selecting a moving technique. Other problems may come up also. Tractors may be unable to maneuver in a congested and narrow space or a structure built into a hillside may defy efforts of cribbing and jacking.

Moving Intact

The relocation of a building as a single and intact unit is generally the most desirable method (figure 20). Not only are the labor costs of dismantling and reassembling avoided, but more importantly, the original fabric is preserved (figure 21). No matter how skilled the artisans who disassemble the building, the loss factor increases with the scope of the dismantling process.

Total Disassembly

When a braced frame house is completely disassembled, all the plaster and all the original clay or lime mortar from the chimney stacks and foundations will be lost. Even the original lath may be unsalvagable. In dismantling a log structure, all original chinking will be destroyed and must be replaced with new material, meaning that perhaps only 50% of the reconstructed building will be original fabric. The extent of loss of wooden elements varies, depending upon the condition and character of the various components. It may not be possible to spread frame members sufficiently apart to disengage mortise-tenon joints and the expedient of sawing tenons and drilling out treenails (wooden pins which secure major frame joints) may be a last recourse. Clapboards and exterior sheathing become brittle with age and often cannot be removed intact. Finish work may be marred by inexperienced carpenters during dismantling and the risk of breakage, even with skilled and sympathetic personnel, is always present.

Breakage and consequent loss of masonry units varies, depending upon the potential friability of the masonry units themselves and the nature of the mortar (figure 22). Most mortars used after the third quarter of the 19th century contain some portion of Portland cement. These mortars, because of their strength and bonding capabilities, are very difficult to remove from most stones, such as sandstone, marble, and from brick. Even with minimal attrition, the texture and coloration of the original masonry wall is extremely difficult to reproduce faithfully. Aside from the actual physical loss of original fabric, which cannot be avoided during the complete dismantling of a structure, there is the very unfortunate loss of the originality that is part of an undisturbed building.

If there is a positive factor in the total dismantling of a structure, it is that the technology and the growth pattern of the building may be studied and recorded in detail. Frequently, it is only through complete disassembly of a structure that hidden features of construction or clues to structural evolution come to light. In this fashion, a growing body of architectural and technological knowledge is gradually developed, providing of course, that such information is carefully recorded. But total dismantling should still be looked upon as the last resort.

Figure 20: House moving in San Francisco

On three successive weekends in November 1974, twelve late 19th-century frame houses in San Francisco, such as the ones pictured here, were moved intact from their original locations within a "fire zone" to the Western Addition, a section of the city in which wood frame structures are permitted. These structures had been put up for public sale in 1972 by the San Francisco Redevelopment Agency (SFRA) as part of an ongoing effort to decrease the threat of fire by removing all frame buildings from this area of the city. The houses were purchased by the Foundation for San Francisco's Architectural Heritage, which in turn found buyers for the buildings. The new owners were required to demonstrate the ability to pay for the costs of purchasing the relocation site, installing a new foundation and utility hookups, and restoring the houses, but the move was carried out by the SFRA. Because all of the houses had been designated city landmarks and/or were listed in the National Register (through the efforts of the SFRA staff), the SFRA was eligible to receive Federal funds to help defray the costs of the move. [Photographs: Jeremiah O. Bragstad for the San Francisco Redevelopment Agency]

Figure 21: Alexander Clark House, Muscatine, Iowa

In planning the relocation of a structure that has been enlarged several times over the years, it is often assumed that the additions (especially if they are of masonry), will have to be removed from the main section of the building and moved separately. One can see from this photograph of the Alexander Clark House that it was successfully moved with its several "appendages" still attached, thus avoiding the problem of rejoining them to the main building after the relocation. [Photograph: Courtesy of Elizabeth Leach]

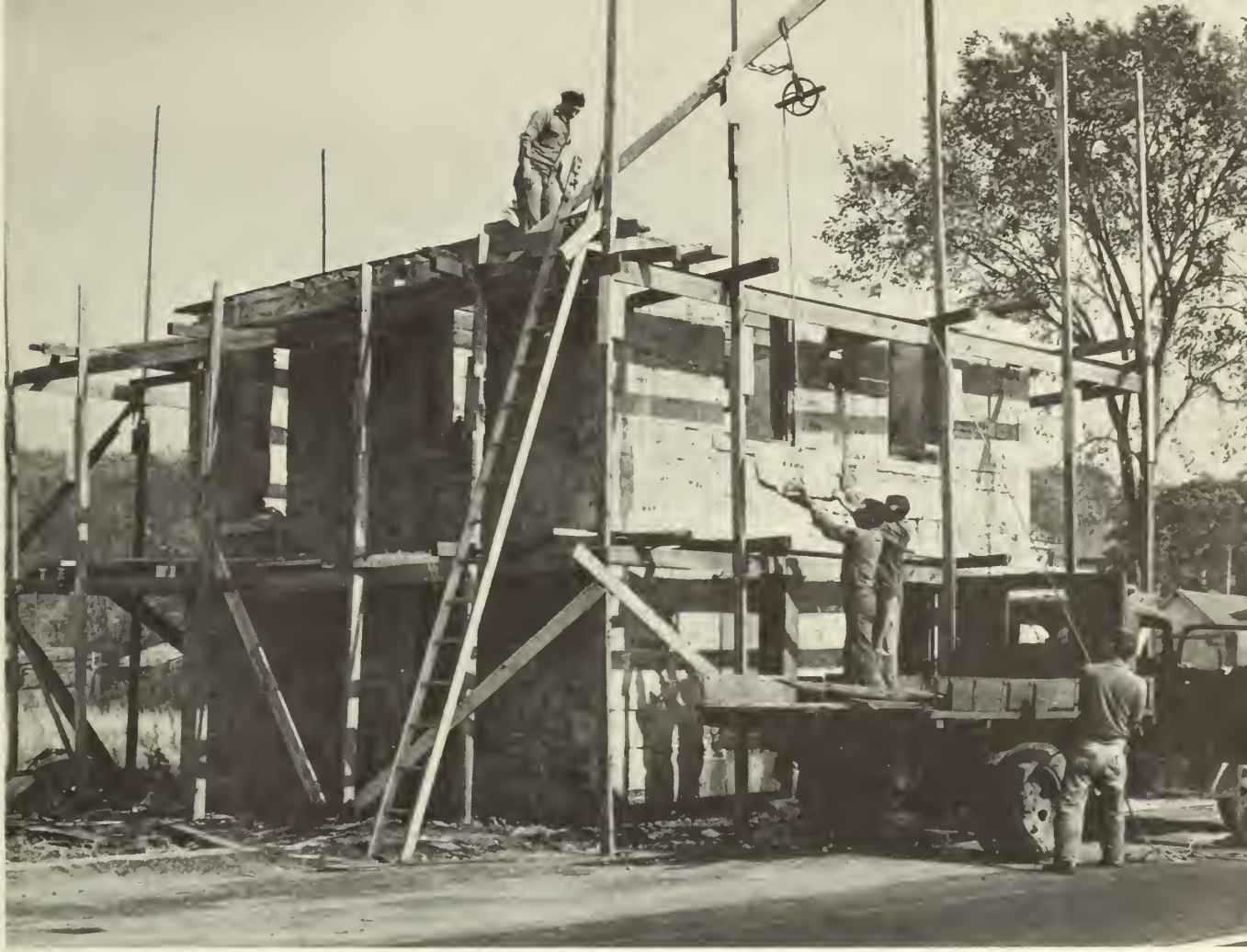


Figure 22: Disassembly of a stone masonry building in Mystic, Connecticut

The 1833 Mystic Bank, a stylistic mixture of Federal and Greek Revival, was acquired by Mystic Seaport, Inc. in 1947, following almost 70 years of disuse. In order to move the structure, each of the building stones was carefully marked according to orientation and numerical arrangement. Then the building was disassembled stone by stone, and reassembled on the grounds of Mystic Seaport where it remains the second oldest bank building in Connecticut. [Photograph: Courtesy of Mystic Seaport, Inc.]

Partial disassembly of a frame structure

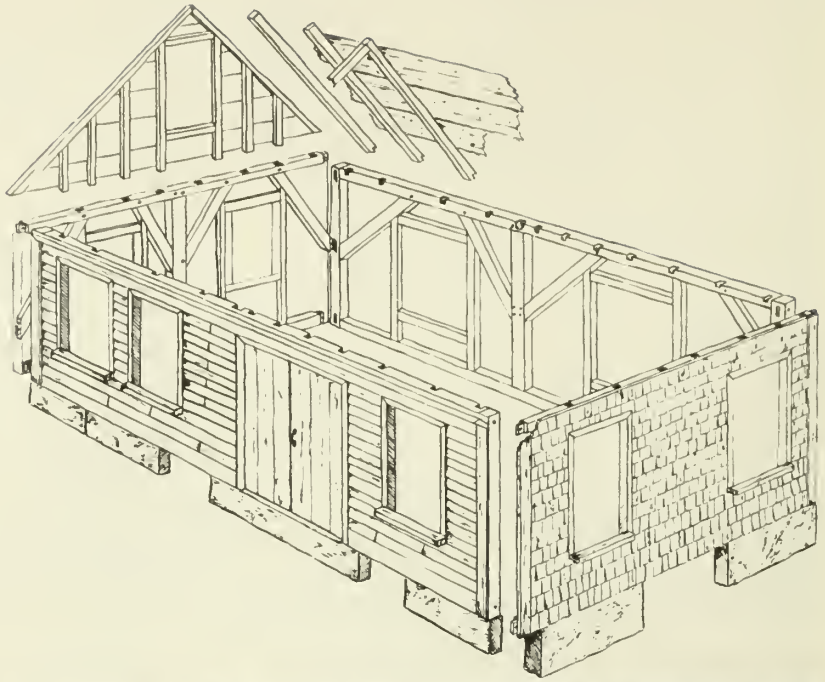


Figure 23: A schematic drawing of the circa 1830 Hapgood Carding Mill in South Waterford, Maine, details a method of partial disassembly. Roof components must be marked and disassembled in their entirety prior to separating the remainder of the structure into six major elements. [Sketch by John O. Curtis, Old Sturbridge Village]

Figure 24: The entire gable end of the Hapgood Carding Mill is handled as a unit in a partial disassembly. [Photograph: John O. Curtis, Old Sturbridge Village]

Partial Disassembly

Partial disassembly, with emphasis upon handling the structure in the largest workable pieces, is an alternative that combines favorable aspects of both previously discussed extremes. A story and a half braced frame building, for example, may be separated into six major components: the front and rear walls, the two end walls, and the two gables (figure 23). Disassembly of the roof and floors must, of course, be completed first, and interior nonload-bearing walls may, with supportive bracing, be handled as whole units. Two major advantages of partial disassembly are that time and labor costs are reduced and the potential loss of fabric is minimized (figure 24).

Larger frame buildings may also be moved in sections, but the procedure requires extensive subsidiary bracing, since major elements common to two walls cannot support both walls as they are separated for the move. Temporary splints may be required to brace wall units pierced by doors or windows (see figures 1, 5, 38, and 41). A crane will be needed to move a structure which has been separated into sections (figure 25). Renting a crane is expensive, but it may actually save in the long run by eliminating the labor costs involved in dismantling a building. However, preparations for this sort of move must be planned well in advance. Frequently, masonry buildings are partially disassembled for a move so that the main block of the structure can be transported as one unit, while the roof and other frame appurtenances are detached and disassembled.

Figure 25: Using a crane to reassemble a wall unit

Using a crane, the entire end wall of the Hapgood Carding Mill is hoisted into position atop a reconstructed foundation (at left) and timber cribbing (at right). Partial disassembly of a frame building expedites reconstruction and conserves original fabric. [Photograph: James C. Ward, Old Sturbridge Village]

Planning The Route

Selection of the route to be taken during the relocation of an intact structure must be made well in advance of the actual date of the move. Moving an entire building usually requires wide roads and a travel route planned to circumnavigate low underpasses or narrow bridges with insufficient load-bearing capabilities. Although extremely steep gradients should be avoided for obvious reasons, moderate inclines may be traversed by using three truck tractors in appropriate combinations: two pulling uphill or, alternatively, two acting as anchors behind the load to brake the descent (see figure 39). Remember, maneuvering tractors and a building requires space (figure 26). Availability of overhead space must be considered, too, and arrangements must be made by the contractor with telephone and electric companies to raise or temporarily remove overhead wires. This will necessitate a careful survey of the utility poles along the entire route to be traveled, coordination of utility company work crews with the moving schedule and, usually, an hourly fee for their services.

Moving and road use permits will probably be required by the several communities through which the building will pass. These generally can be obtained through either the state or local highway departments. The proposed travel route should be planned in cooperation with, and cleared by, the appropriate state and local police departments. Their services should be scheduled for escort and traffic-control duty during the actual move. If the duration of the move is likely to take several days, traveling at an average speed of 3 to 4 miles per hour, then provision must be made for surveillance or police protection while the structure is parked during the intervening nights. In planning the travel route for a move of several days duration, parking sites should be carefully selected and permission for their use secured in advance. In some areas, especially in cities, building moving must be done at night rather than during daylight hours; thus, provision must be made for daytime parking accommodations (see figure 26).

Some tree limbs may have to be removed along the route; permits from the municipality as well as the services of the local tree warden may be needed. If trees are privately owned, permission for cutting will be necessary and some remunerative costs may well be entailed.

Similar precautions must be taken when relocating partially or completely disassembled buildings to those followed when moving an intact structure. Careful and detailed route planning should be completed well before any actual moving begins. The route and mode of transport selected will depend upon the size, weight, and conditions of the dismantled building sections. Storage facilities, secure against the weather and vandalism, should be provided at the new site for the more perishable components prior to reassembly.

Figure 26: Housemoving in tight spaces

This view of another of the twelve Victorian houses relocated by the San Francisco Redevelopment Agency (see figure 20) clearly illustrates two difficulties attendant on moving buildings in built-up urban areas. Space in which to maneuver heavy equipment and the building itself may be severely limited, making the move more difficult, but no less attainable. Secondly, the move itself may have to take place at night, in order to avoid massive traffic tie-ups and rush-hour delays. [Photograph: Jeremiah O. Bragstad for the San Francisco Redevelopment Agency]

Documentation

It is important that thorough documentation and recording of the move and/or restoration of the property be carried out in every phase of the work, particularly if a structure is to be dismantled. There are essentially four different aspects of this research, which may be divided as follows.

Historical Background and Research
Field Notes and Physical Investigation
  Archeological Research
  Architectural Research
Recording the Disassembly and the Move
Restoration Notes and Maintenance Records

Historical Background and Research

Documentary sources serve a dual purpose; they both suggest what may be found in either the architectural or archeological surveys and substantiate what is found during physical exploration of the fabric. Occasionally, documentation such as old photographs or archeological data may provide the only clues to missing features of a structure or site. Historical research includes a land title search to establish a chronological sequence of ownership, usually working back from the most recent to the earliest deed. While particularly difficult titles may require the assistance of a lawyer, one can generally research the title unaided, relying upon either the assistance of records office staff, or an indexing system based upon the grantor's (or seller's) name and the grantee's (or buyer's) name. Land transfers are generally recorded in the county seat, although in some states they are maintained by the town clerk.

A title search may provide an initial construction date for the building, because deeds usually define the land boundaries and list "buildings or appurtenances thereon standing." Thus, a title searched back to a point when structures are no longer mentioned may provide a time frame during which construction may have occurred. However, there is a fallacy inherent in depending solely upon such documentary data, for the building presently standing upon a site may be the second or third built upon the same parcel of land. In fact, the building might be one that had been moved there years before. A portion of a building might have been moved onto the property, or attached to an existing structure already on the property—a practice common in New England during the 18th and 19th centuries.

Once a chronology of owners is established, the researcher can turn to other documentary sources for additional clues to structural changes or the physical evolution of the building (figure 27). If extant, tax records, assessors' records, and insurance records may be valuable in that they usually contain somewhat more detailed descriptions of the structure. References to square footage of ground plan, number of stories, type of construction, number of windows, number of chimneys or fireplaces, and outbuildings are often contained in these records. If authentic furnishing of the building is contemplated, then a search of probate inventories should be conducted in the county probate records office to see if the pertinent estates were inventoried at the time of death of the owner(s). Such room by room inventories are not only of great assistance in developing furnishings schedules, but also they may provide clues to former decorative treatment of particular spaces through brief descriptions. In the case of those former owners who did not die intestate, registered wills may provide the same types of information.

The procedures outlined above may be dealt with in a reasonably systematic manner in county or municipal records offices or insurance company records. Other avenues of research should not be overlooked. Diaries, ledgers, daybooks, and account books related to a former occupant of the building may be of value. These may turn up in area libraries, historical societies or museums, or in private hands. An effort to contact descendents may generate family papers, old photographs, or prints that will provide restoration clues. Lastly, the conscientious researcher should not rule out oral history as a primary source of information about the building's recent past.

Figure 27: Excavation of a historic site

Site archeology may bring to light significant and vital information about a structure's previous configuration, as in this instance where the earliest part of the building survived only into the opening years of the present century. Through excavation, the dimensions of the ground plan were accurately ascertained and subsequently provided the basis, along with old photographs, for an accurate reconstruction of the missing elements. [Photograph: John O. Curtis, Old Sturbridge Village]

Field Notes and Physical Investigation

Archeological Research

Plans by a Federal agency or a recipient of Federal assistance to move a structure listed on or determined eligible for listing in the National Register of Historic Places from its original location usually require that archeological investigations be conducted at the original location as well as at the site chosen for relocation. The purpose of these investigations is to identify, evaluate, and recover cultural and historical data thay may be lost or damaged as a result of relocation. The cultural and historical data obtained at the site of original location may also be used to aid in an accurate restoration of the structure following its relocation.

The first phase of archeological investigation involves an in-depth search of the literature to document past uses of the structure and the site and the known history of the area. This phase is followed by field reconnaissance of the area, often including some subsurface testing. A survey should reveal the presence or absence of transportation networks, foundations of associated structures, refuse areas, wells, gardens and agricultural areas, industrial sites and other features, as well as changes in topography.

If historically significant features are discovered, the State Historic Preservation Officer and the Advisory Council on Historic Preservation must be consulted in order to determine ways in which these features may be preserved. At one end of the spectrum of alternatives available, project plans may be modified so as to avoid destruction of significant archeological materials. At the other end of the

spectrum, if project plans cannot be modified, a data recovery program may be initiated. Since archeological excavation is by its very nature a destructive process—a site cannot be "reexcavated" when new archeological methods and techniques are developed—it is obviously more desirable to preserve a site intact rather than to excavate it. The effects of the proposed actions on archeological and historic sites should be considered early in the planning process. The alternatives which have the least impact upon cultural resources should be fully investigated. If there is no feasible alternative to moving the structure from its original location, archeologists should be able to recover, through salvage excavations, data about past living patterns and building sequences that might not otherwise have been preserved. The materials recovered might be retained for exhibition within the structure itself, if the building is to be restored and opened to the public as a period museum, or they might be donated or loaned to a local historical society or museum.

Archeological resources are nonrenewable and become valueless out of context. All archeological investigations must be performed by qualified professionals, using appropriate methods and techniques. Minimum standards of qualification for professional archeologists may be found in Part 3 of 36 CFR 61 (Criteria for Comprehensive Statewide Historic Surveys and Plans) or by contacting the Society of Professional Archeologists. Because the preservation and proper curatorial care of archeological resources require the expertise of specialists trained in restoration and preservation techniques, Federal agencies involved in moving a structure should contact the State Historic Preservation Officer or Interagency Archeological Services (Heritage Conservation and Recreation Service, U.S. Department of the Interior, Washington, D.C. 20243) for technical advice.

General guidelines for survey, data recovery, analysis and curatorial care of artifacts, and for compilation of reports may be found in **The Archeological Survey: Methods and Uses** (HCRS, 1978), and in other guidelines and procedures issued from time to time by the Department of the Interior.

Architectural Research

Photography is a very useful architectural recording method and an invaluable aid in architectural research. A thoroughly documented project will generate large quantities of prints and slides, which must be identified by accurate descriptive labels. Photographs should accompany the textual records of the field and restoration notes, and usually should be organized in a chronological sequence. A thorough photographic survey of the entire structure should be made prior to commencement of any physical work, either exploratory or in preparation for the move. Included in the comprehensive series should be site and location views from all quarters, exterior elevations on all sides, interior elevations of every wall of each room and elevations of each basement and attic wall. Special detailed photographs should be made of noteworthy decorative architectural embellishments, such as pediments, chimney breasts, cupboards, stairways, door hardware and exposed structural features.

It is best to use a view camera having tilts and swings for architectural work, and a 4 by 5 inch sheet film format should be adopted, particularly for the black and white work. Negatives and prints should be processed to archival standards to ensure maximum stability and permanence. Color work transparencies may be 35mm, although 2¼ by 2¼ inch roll film can be used in an appropriate roll film back on a view camera. If possible, take both black and white and color photos, as most color will fade. Both slides and prints should be promptly dated and labeled to prevent future confusion. In special instances, X-ray photography or radiography may clarify uncertain details of construction technique and eliminate the need for damaging and time-consuming exploratory probing of the physical fabric. (For a more thorough discussion of this subject, see David M. Hart's Draft Report, **X-Ray Examination of Historic Structures.**)

Other specialized photographic tools applied in architectural recordings are stereo photogrammetry and rectified photography. One of the advantages of stereo photogrammetry is that through its application, many structures which could not be recorded by hand-done measured drawings because of an inaccessible location, unstable and dangerous structural condition, or which are threatened by imminent demolition, can be captured photographically. Stereo photogrammetry utilizes

stereopairs (two separate photographs) taken at a precise distance apart.

Through the application of highly sophisticated instruments, the perspective views of the building recorded on the stereopair can be interpreted in a two-dimensional orthophoto, showing the plan and elevation. (See Perry E. Borchers, **Photogrammetric Recording of Cultural Resources.**) Rectified photography is a less complicated application of architectural photogrammetry, and is most frequently used for taking perspective-free photographs, such as that of a building façade. Photographs taken in this manner can be printed and enlarged to an appropriate architectural scale as a basis for working drawings, surveys, and feasibility studies. (See J. Henry Chambers, AIA, **Rectified Photography and Photo Drawings for Historic Preservation.**)

When X-ray photography, stereo photogrammetry, and rectified photography are beyond the capabilities and budgetary parameters of many agencies or individuals, measured drawings may be prepared inexpensively by a qualified draftsman. A full set of measured drawings should include interior and exterior elevations of all walls, plans of each level, sections through both axes of the building, and a complete framing scheme, and decorative trim details and moulding profiles. "Exploded" isometric views will clarify frame joint details, and if the building is to be moved in sections, can also graphically specify and record the techniques. A site plan of the original location showing related features such as walks, gardens, outbuildings, walls, and yard furniture such as well heads, hitching posts, urns and fountains, is an integral part of this series of drawings. A topographical plot recording gradient changes and other physical features should also be made either as part of the measured drawing series or as a phase of the archeological site survey. In the interests of consistency, the Historic American Buildings Survey format discussed in **Recording Historic Buildings** by Harley J. McKee, should be adopted for all drawings.

Recording the Disassembly and the Move

If a structure is to be either partially or totally disassembled for the move, great care must be taken during this process to ensure accurate reassembly after the relocation. Sequential disassembly of a building is relatively uncomplicated but requires special attention in marking all parts of the building as they are separated from the whole. Of course, there should be regular and frequent photographic coverage. As with the other phases of documentation, all photographs and slides taken of the dismantling process should be labeled with a description of the building element shown and its location within the structure. It is equally important to note the building's orientation and siting on the property; this is particularly necessary if the intent is to recreate the building's former setting during the reassembly of the structure at its new location.

Restoration Notes and Maintenance Notes

The research data, which includes the architectural field notes and drawings, the archeological findings, and the documentary information is necessary in guiding and directing the reerection process; but if the structure is to be restored, the restoration notes and the maintenance records are imperative to support and explain the finished project. A building restoration may be compared to a theorem in geometry in that it must be proven and each aspect of the work and each decision governing it must be carefully substantiated and supported by physical evidence and other facts. If the specifics pertinent to the particular building are not available, then the restoration should be based on clear and plausible citations of similar buildings contemporary in style and period. The overriding consideration in any restoration should be that the building is being moved and restored for the future as well as the present. Future historians and building technicians should be able to see the decision-making processes of our era, and be spared the confusion and inconsistencies of an undocumented project.

For this reason, a careful record and schedule of the maintenance procedures followed in the restored structure should be kept and made accessible to future researchers. A major aim of any preservation and maintenance program is to avoid causing any irreversible changes to the restored building through the day-to-day housekeeping. **Cyclical Maintenance for Historic Buildings**, by J. Henry Chambers, AIA, is a useful guide to preparing a maintenance plan.

Interim Protection Prior To The Move

Before proceding further in the relocation process, a thorough survey should be made of the structure to assess the physical condition of the building's frame and "skin," not necessarily as a restoration planning tool, but rather to discover and treat chronic situations that could develop into serious restoration problems if left unchecked. Included in this initial conservation examination should be a determination of the extent of active insect infestation, or materials deterioration due to dry rot or water damage.

Weatherproofing the Structure

Watertight integrity is as important to the survival of a structure as it is to the survival of a ship. Maintenance of a sound roof and prevention of the intrusion of potentially harmful ground water or eaves runoff should be initial "first aid" considerations if the structure is not to be moved or dismantled right away. If the conditions warrant, temporary roof repairs should be made to protect interior plaster, floors and frame. Modern gutters and leaders can also be installed temporarily to conduct water away from the building. Collapsing foundation walls should be braced with timber shoring to equalize the pressure on both sides of the masonry wall and to prevent subsidence until permanent measures can be taken.

If the structure has been heated in the past, a minimal temperature of 50° F should be maintained if possible during cold weather. This will prevent dampness from damaging plaster and the acceleration of dry-rot activity which thrives in moist conditions. For the same reason dehumidifiers should be installed in customarily damp areas during the summer months before the move.

Protection from Vandalism

Vandals or scavengers present a constant threat to any unoccupied structure, whether in a rural or urban context. If the physical condition of the building permits occupancy, there is no substitute for a resident caretaker. Alternatively, sympathetic neighbors may be enlisted to maintain a measure of surveillance, but their part-time protection should be augmented by a full-time intrusion and fire-detection system. Time need not be wasted on installation of a sophisticated and unobtrusive system in an unrestored structure because protection is the primary consideration. However, this installation should not damage the historic building fabric unnecessarily. Circuit-breaking magnetic catches at door and window openings are of relatively little value, as it is possible to cut away a section of a door or sash large enough to permit entry without disturbing the catch. Where feasible, such protection systems should be connected by an automatic telephone signaling device to police and fire stations. Where this cannot be done, some lesser degree of protection may be provided by visual as well as audible alarm devices on the exterior of the building.

Covering the door and window apertures will prevent glass loss and provide some minimal deterence to intruders. A composition board, sealed with paint against the weather, or plywood may be used. It is recommended that the protective panels be applied using nails rather than wood screws; this action will minimize possible damage to trim or exterior finish work should the panels be wrenched off by a determined intruder. As dampness can cause internal damage in a closed structure, provision should be made for air circulation through venting. If adequate ventilation is not supplied by roof vents or chimney flues, holes should be drilled in the composition board or plywood.

A mowed lawn and generally well-kept grounds can provide some protection against both fire and vandalism, but in the final analysis there is no guaranteed insurance against the intruder. Bearing this in mind, some thought might be given to the removal from the structure of its most attractive and vulnerable components such as hardware, doors, mantels, paneling, and sash. If such components are removed, their original location should be carefully documented and the artifacts themselves should be carefully labeled and stored. Weigh the risk of potential loss through vandalism against storage problems, labor costs, disruption (and possible loss) of original fabric, which could occur dur-

ing the process of "preventive removal," and decide accordingly. If the building is worth the effort of moving and restoring, it is worth the effort of preservation prior to the move.

Selecting and Preparing the New Site

Selection of a new site for the relocated structure requires careful planning well in advance of the actual move. It is desirable to find a setting as much like the original as possible (figures 28 and 29). Some earlier architects gave careful consideration to the relationship of the building to its setting. The sensitive preservationist should not compromise a structure's design integrity with a setting that is unsympathetic or incompatible with the original. Buildings of a classical design generally have a principal façade that requires a particular orientation to do justice to the entire structure. (Imagine a prostyle Greek Revival mansion sideways on its lot!) Architects often used mouldings to decorate a building; it is the play of light and shadow that gives these architectural mouldings their distinctive and decorative character. When choosing a site for the building to be relocated, the persons responsible should recognize the important influence that solar orientation can have on the building's artistic and aesthetic quality. If the building to be moved is listed in the National Register, it is doubly important that a compatible site be selected for its new location if the building is to retain this status during and after the move.

In situating a single structure, it is also important to consider the adjacent structures and the site. Shape, mass, and scale are critical; the relocated structure must adapt harmoniously to its new to location if it is not to appear awkward or out of place. Care must also be taken that relocating a building on a particular site does not inadvertently destroy or adversely affect the historical, cultural, or archeological significance of that site.

As a part of the field survey work at the original site, the dimensions of the structure's foundation will have been taken. Notes will have recorded the condition of the foundation as well as the physical state of the building as it relates to its foundation. This will bear strongly upon the choice of the kind of foundation to be provided at the new site.

Generally speaking, the cause of long-term building conservation is best served by a full dry cellar under any structure. If basement spaces are not potential exhibit areas, foundation walls may be poured concrete or concrete block, well sealed on the exterior with pargeting. A poured concrete floor atop a 6–mil polyethylene vapor barrier should complete an adequate foundation for the structure, providing no water table or groundwater seepage problem exists. Should water be present around the perimeter, the floor must pitch to a sump, rather

Figures 28–29: A Suitable site for relocation of the Pope-Leighey House

The importance of relocating a building on a site similar to that on which it was previously located cannot be overemphasized. These two photographs show the Pope-Leighey House, a "Usonian House" designed by Frank Lloyd Wright and built in 1940–41 in Falls Church, Virginia, a suburb of Washington, D.C. In the early 1960s, the owners of the house were notified that the house was located directly in the path of a planned four-lane highway, Interstate 66, and thus would have to be relocated. After seeking the assistance of the National Trust for Historic Preservation, the National Park Service, and other national and local organizations concerned with the problem, the owner eventually decided to donate the house to the National Trust.

This decision was based partly on the fact that the National Trust was able to offer a well-oriented site, from the standpoint of natural topography, landscraping, and seclusion from public roadways. In addition, the National Trust agreed to provide the owner with lifetime tenancy and maintenance of the house at its new site on the grounds of Woodlawn Plantation, a property owned by the National Trust and located in Mount Vernon, Virginia. Howard C. Rickert, the master carpenter who had built the house originally, was hired to supervise the move and reassembly process.

Selecting the proper relocation site is always a significant aspect of building moving, but it is even more important when a Frank Lloyd Wright designed house is involved because of the close relationship between his houses and their natural surroundings.

Comparing the terrain of the original site (figure 28) with the new site (figure 29), one can see that the Pope-Leighey House has indeed been successfully integrated into its new site. [Photographs: Courtesy of the National Trust for Historic Preservation]

than to a drain. Trenches or buried pipe may help in control of seepage. In situations where rising damp presents a chronic danger to the sidewalls of the structure, additional "damp proofing" should be introduced between the new concrete foundation and the original brick or stone courses.

Regardless of the kind of modern materials employed in providing a moisture-resistant foundation, the walls should be designed to accommodate facing with the original brick, fieldstone, or dressed stone for that section of the foundation which will show above the finish grade. To do this accurately, masonry units must have been marked and the thickness of mortar courses measured and recorded prior to dismantling. If, however, it is decided that the basement space is critical to the interpretation of the restored structure, then, if possible, basement walls must be disassembled and moved too.

When dealing with masonry units of sufficient size to make their handling as individual components economically feasible, mark each with a number code assigning it a position "left to right" within a given course of a particuiar wall. When practicable, numbering should be done in a permanent medium such as red lead on top surfaces which will be covered and hidden by successive courses. (figure 30. See also figure 22.) Individual stones should be padded with burlap or scrap wood in order to prevent abrasion by chains or cables during removal and subsequently during travel. Obviously, a brick or rubble foundation does not lend itself to transfer by this technique, and the best that can be done is careful dismantling and salvage of materials. The foundations would then be relaid in mortar mixed to match the original with care taken to replicate the original bond in both composition and color as well as textural character.

There is another technique for preparation of the new moisture-resistant foundation. If the original masonry units are small enough, it is possible to utilize them as an interior or exterior facing for a poured concrete or concrete block foundation. In this fashion, the appearance of the old is combined with the stability and watertight integrity of the new. An obvious disadvantage of this procedure, however, is that the irregular configuration of fieldstone or some rubble masonry units may preclude their even alignment against the new foundation wall. Because conservation of the historic structure must always take first priority, "dry-laid" rubble walls should be pargeted or grouted and sealed on the outside of the foundation below grade to achieve watertight integrity.

If a building is totally dismantled for the move, the method used to provide its new or reconstructed foundation is not critical; a plumb, square and level foundation is usually acceptable as good building practice, as long as the structure was not built out of square originally. Should the latter be the case, the new foundation will have to be laid to conform to the irregularities of the building it is to support. When a structure is moved as a unit, however, thought should be given to the potentially harmful effects of lowering it onto a perfectly level footing. While a frame structure will rack to a degree, accommodating itself to the supporting substructure, the immediate effect of lowering a masonry building onto a prepared foundation can be the development of disastrous cracks. To avoid problems, the building should be supported on cribbing at the requisite height above the footings and the foundation walls built up to meet and conform to the irregularities of the existing sidewalls. This procedure is imperative for masonry structures. It may also be deemed necessary in those instances where it is desirable to preserve those physical manifestations of great age which are evident in a frame building that has settled.

Figure 30: Identification systems for reassembly of stone walls

The unique character and disposition of rubble or fieldstone masonry requires a careful marking system to assure proper realignment during the reassembly process. In this instance, an impromptu chalk marking system was utilized to expedite the removal process. Stones were subsequently assigned identification numbers which were painted on the top surfaces.

For cut-stone masonry, a simple system of numbers and letters (to indicate orientation) may suffice, but it is important that the numbered wall be photographed prior to disassembly to facilitate reerection. [Photograph: John O. Curtis, Old Sturbridge Village]

Preparing The Structure For The Move

Moving Intact

If a building is to be moved intact and handled by a contractor in the conventional manner, workmen will prepare the building for jacking, loading and transporting. In frame buildings, structural repairs or temporary remedial measures must be taken to replace or splint deteriorated sills and side wall framing. Where possible, supporting planks or timbers may be attached to frame members to add strength in bridging deteriorated sections. Where this is not possible, it may be desirable to resill or make major structural repairs at the original site in order to assure a safe and stable move. If there is potential hazard of abrasion to original exterior fabric of the building, protect the side wall and roof surfaces by nailing on sheets of homasote board or plywood (figures 31 and 32). The same material may be used to cover windows and doors if those elements are to remain in situ during the move.

Figure 31: A protective crate for moving the Thompson Bank to Old Sturbridge Village

This small brick masonry bank building has been prepared for removal as a virtually intact unit. The columned portico has been disassembled after careful recording and marking. All roof components down to the plate level are marked and dismantled. When all preparatory work is completed, the foundation is pierced and the jacking process commenced in order to position multi-wheeled moving dollies beneath supporting steel beams.

The sandwich "crate" used for this particular building consists of plywood and cleats (inside and outside) which are held together with bolts through the brick masonry. Voids between the masonry surfaces and the plywood sandwich were filled with insulating material blown in under high pressure to assure firm support between the sandwich and the brick walls. [Photographs: John O. Curtis, Old Sturbridge Village (left) James C. Ward, Old Sturbridge Village (right)]

Figure 32: Lenthall Houses, Washington, D.C.

A much simpler bracing system provided adequate support for these attached brick houses when they were moved to make room for construction of a large office building in 1978. The structure has been "crated" with steel cables. The tensile stress of the cables is transferred to the masonry shell through the vertical wooden braces. Cable ties attached to exterior horizontal wooden members are stretched from front to rear through the windows for additional support. [Photograph: John Myers]

Moving Partially Or Totally Disassembled

Where building height or width preclude a fully intact move, it will be necessary to dismantle elements such as chimneys, roofing, and roof framing. Detailed and comprehensive photography is imperative and all features being disassembled must be carefully marked to guide reassembly.

In a situation where a structure cannot be removed from its site as a whole unit, the disassembly process and the actual move occur in successive stages. If necessary, removal of all potentially problem-causing structural projections such as porches, porticos, or bay windows should be done prior to the move. To safeguard original sash or exterior doors in transit, it may be necessary to remove them prior to the move. Lastly, the whole building may, if deemed necessary, receive additional bracing to prevent racking during the raising and moving process. Planks or timbers nailed or lag-screwed diagonally to the exterior create rigid triangles that will prevent shifting or deformation of the structure (see figures 1, 5, and 37). Internally, timbers securely bolted to create "Xs," situated diagonally from floor to ceiling, will have the same effect.

In order to prevent any measure of confusion in marking terminology, compass points of the structure's original orientation should be established at the outset so that all personnel involved in the dismantling and reassembly processes are in accord as to which side is indeed north. Contrasting colors of either acrylic or latex paint or carpenter wax crayons should be selected, using a different color for each side. Chalk is not advisable because it rubs off and washes off easily. A marking code may be developed to suit the situation, but it should be simple and standardized throughout the project. Foremost should be the consideration that all marking must be removable or must be done on surfaces that will be hidden during reassembly. Thus, roofing boards marked "R–E–1," "R–E–2" would be those at the ridge and the next course immediately below on the east slope of the roof.

With a single color used consistently on a given area, spot identification of all related components is assured. To facilitate accuracy in positioning during reassembly, a bold diagonal line should be drawn prior to dismantling across any sheathed surface, such as the roof or side walls.

Large masonry units may be marked as to their location within a wall or course. Ideally, such marking should be in a permanent medium, such as red lead, and done on top surfaces which will be hidden by successive reassembly of the wall. This method cen be used for walls, foundations, or chimneys. As stated earlier, thorough overall photography is vital, as are measured drawings in which each masonry unit is detailed and labeled with an appropriate identifying number. Small masonry units, especially bricks, tend to defy systematic and sequential dismantling and reassembly, simply because of the sheer volume involved and the consequent prohibitive labor costs. Brick work may be taken down, salvaging as much as possible; joint and mortar course widths and thicknesses can be measured to attempt a reconstruction which approximates the original.

Having established a marking methodology, one should return to the proper sequence of building dismantling. As removal of the roof or protective side wall covering will disturb the structure's watertight integrity, all interior finish woodwork should be carefully marked and removed beforehand. Sash may be marked on their vertical edges (a marked light of glass can be broken out) and the corresponding marking code placed on the part of the window reveal customarily covered by the sash when it is properly replaced. Doors and frames can be marked in a similar fashion. The rooms themselves must be identified; compass orientation for designation of each wall of a room is critical. Thus "P" may designate parlor, "PC" parlor chamber for the room immediately above stairs, "K" for kitchen, etc. Alternatively, rooms may either be numbered by Roman numerals or, if there are but a few special-purpose spaces within the structure, by appropriate abbreviations such as "SR–W" (salesroom, westside), or "CR–E," (counting room, eastside). The marking system for each building will naturally vary, as do buildings. A set of plans should always be at hand during the marking process, and, in every possible instance, drawings should be marked in a manner which corresponds with the actual decorative or structural components which they illustrate.

After all interior finish work, plaster and lath, and finish floors are marked, removed, denailed, tied in bundles (where feasible), and loaded in closed vans for transportation, dismantling of the building's protective skin and structure can commence. Roofing boards should be marked on their top surfaces after removal of shingles or other sheathing. Rafters are then numbered after removal of roofing boards. Plates and ties are numbered on their top surfaces after attic floorboards are numbered and removed. Clapboards, if sound and salvagable, may be numbered. A large percentage of clapboards and split lath may be salvaged and reused if removed with care. A broad-bladed pry bar may be used for this purpose, but a more specialized instrument may be needed for stubborn nails.

The uncovered structure may be protected from the elements by tarpaulins or polyethylene once the roof is removed (see figures 19, 35 and 38). This degree of protection may not be required in every case, since all vulnerable interior fabric will have been previously removed. During dismantling, side wall subsheathing should be retained on a floor-by-floor basis for the support it provides the frame during disassembly. Additional support may be afforded by appropriately spaced diagonal braces bearing against the wall, securely fastened to "two by fours" driven into the ground. Frame-joint pins should be driven out wherever possible; drilling them out means loss of original fabric, and cutting tenons is the least desirable expedient. Lengthy posts or studs should be lowered to a horizontal position with care; old and dry timbers will often shatter or crack if subjected to a sudden impact. To simplify the work and minimize damage to structural components during dismantling, small forklift trucks, such as those used for handling goods in warehouses, can be rented or borrowed. They are invaluable in lowering horizontal frame elements. These lifts can move even massive timbers with considerable facility. As the dismantling process moves down from floor to floor, the forklift can be readily lowered to the next level and positioned in place on sheets of 1-inch thick plywood. This procedure will adequately accommodate and distribute the weight of the timber being handled.

In those rare instances where it is desirable to move an entire plaster wall intact because of dec-

orative painting or other decoration, it will be necessary to make some compromise decisions about preservation of original fabric. If the wall surface is of primary importance, then the maintenance of the originality and structural integrity of its support members becomes secondary. The decorated wall should first be protected or faced with paper; cushioning the wall with a resilient paperboard such as homasote would provide even more protection. In order to remove a wall intact, it is necessary literally to cut it out of the fabric of the building. Baseboards and other interior trim elements are removed. In the case of exterior walls, clapboards are removed as necessary, to expose sheathing. In the interest of overall rigidity of the wall unit, sheathing should be retained in situ; and it is generally necessary to provide additional diagonal braces. Note particularly that all bracing should be fastened to the wall frame with long wood screws, rather than nails, to avoid plaster damage caused by hammering. With the wall "unitized" by thorough sheathing and supported by diagonal braces, it is now possible to cut the frame joints. Occasionally, it is possible to lift the wall unit with a crane and disengage the joints of the posts and studs.

The plate, or girt if the wall is from a first floor location, will move with the wall. Obviously, supplementary temporary frame elements must be provided until the structure is reassembled. Braces on both sides of the wall may be through-bolted using lengths of one-half inch diameter threaded steel rod. For this reason some areas of clapboarding might be removed from the exterior. The precaution of through-bolting of braces provides additional rigidity for the whole structure and assures even distribution of pressure against the cushioning medium. Reassembly of walls moved in this manner will require the design of individually custom-fabricated steel fishplates and braces which, when lag-screwed or bolted at the appropriate locations, will replace those wooden joints which had to be cut.

All frame building components, when packed in closed vans, should be fumigated prior to reassembly. In those particular instances where a part of a building is simply in a state of deterioration too advanced to move at all, special care should be taken to photograph and record all dimensions, surface finish, and types of wood to ensure an accurate reproduction.

Conclusion

Whether the structure is of masonry or frame construction, the planning, research, and recording phases of the project are essentially similar; to the relocated and restored structure, they are as significant as the move itself. However, maintaining complete records does not end with the completion of the move. The siting, foundation construction, building reassembly, and restoration phases of the work also require thorough documentation. Only through such attention and careful recordkeeping can the future validity and integrity of the move and restoration be assured.

Case Study
Relocation of the Gruber Wagon Works

Charles A. Parrott, III

The Gruber Wagon Works in Berks County, Pennsylvania, built in stages over the years 1882 to 1911, is a rare surviving family-operated factory, complete and unaltered since the early 20th century. Virtually all of its original machinery remains intact (figures 33 and 34). Its operation, the manufacture of wooden farm wagons, began to decline in the mid-1920s, with the last wagons built by the early 1950s. The buildings and all their tools, machinery, power generating and transmission equipment were still used occasionally for repairs until the early 1970s. Following its closure, the Wagon Works began to deteriorate more rapidly, and there was the added threat that the machinery and tools might be sold and dispersed. The factory buildings were more immediately threatened, as they were in the middle of an impoundment area scheduled for inundation by the U.S. Army Corps of Engineers as part of the Blue Marsh Lake Project.

However, plans for the implementation of the

Figure 33: The Gruber Wagon Works, Berks County, Pennsylvania

An exterior view of the Gruber Wagon Works as the complex appeared in 1976 on its original site, and before its partial disassembly and relocation. The move was necessitated by the planned impoundment of this area for the Blue Marsh Lake Project by the U.S. Army Corps of Engineers. [Photograph: Courtesy of John Milner Associates]

Blue Marsh Lake Project brought attention to the historical significance of the Gruber Wagon Works in the late 1960s. Concern for its future led to its listing in the National Register of Historic Places in 1972, and its documentation and recording by the Historic American Engineering Record (HAER) from 1973 to 1975.

In the meantime the Corps of Engineers, aware of its responsibilities under Section 106 of the National Historic Preservation Act of 1966 (P.L. 89–665), and Executive Order 11593, "Protection and Enhancement of the Cultural Environment," was investigating possible ways to save the Wagon Works. These efforts were intensified by the implementation of the Archeological and Historic Preservation Act of 1974 (P.L. 93–291), commonly known as the Moss-Bennett Act. It provides for the recovery, protection, and preservation of historical and archeological data which might otherwise be lost as the result of any Federal or federally licensed project.

Preservation in this instance meant that the principal structures comprising the Wagon Works would have to be moved. Yet a relocation and restoration project of this magnitude would require considerably more funds than the 1% of project costs that the Corps was authorized to spend by the Moss-Bennett Act on all historic and archeological resources endangered by the construction of a dam. Because of the significance of the Wagon Works, the matter received additional congressional support, and in October 1976, legislation was passed which authorized the expenditure of separate funds specifically to relocate and restore the Gruber Wagon Works.

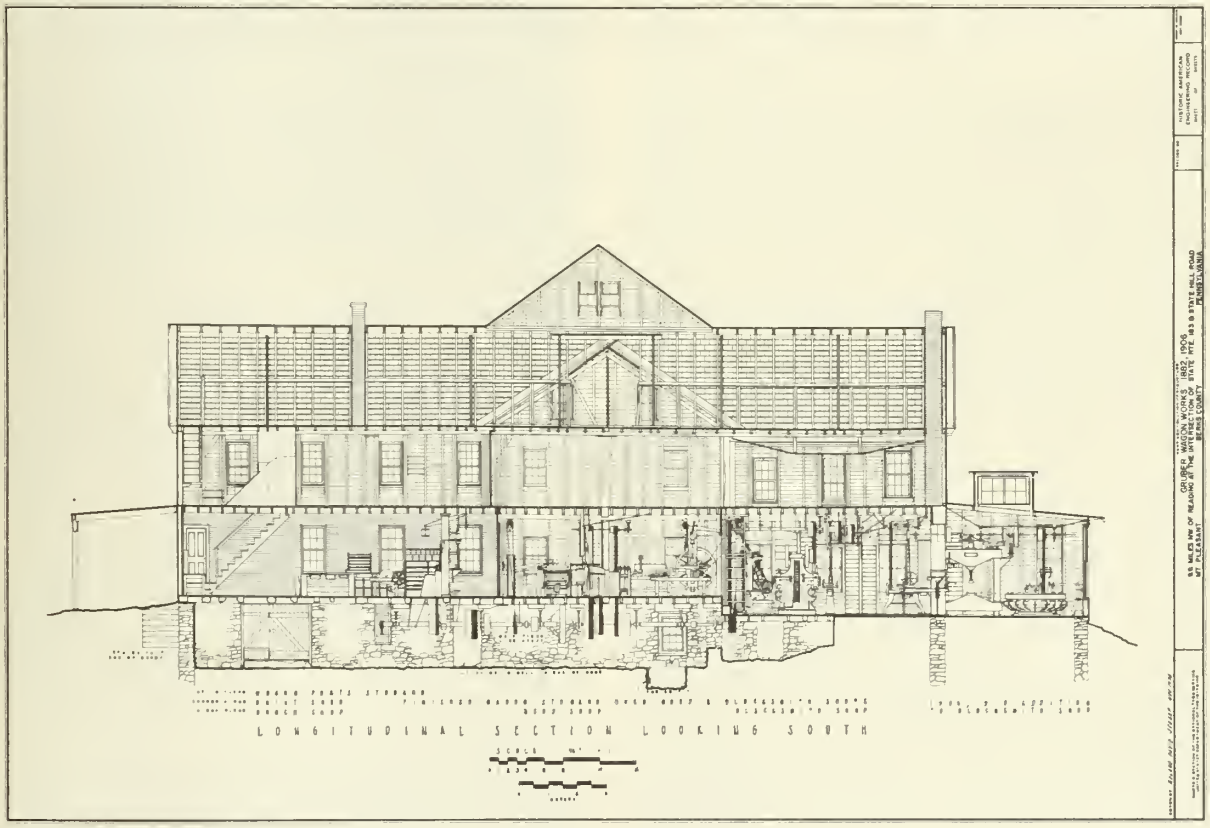


Figure 34: Measured drawing

This longitudinal section looking south is one of the drawings done as part of the Historic American Engineering Record (HAER) project to record the Gruber Wagon Works. This detailed drawing (one of ten sheets), provides information on the location of the machinery used to make wooden wagons. [Photograph: Courtesy of the Historic American Engineering Record (HAER), Roland David Schaaf, Delineator]

Before any major relocation work could begin, much preparatory work had to be done. As early as 1974, the Philadelphia District of the Corps of Engineers began to study the many factors involved with moving the Wagon Works, such as relocation sites and some methods and techniques which could be employed for disassembly or moving intact. The Corps prepared a case report encompassing detailed analyses of five relocation sites and five alternate relocation methods. The case report was prepared for the review and comment of the Advisory Council on Historic Preservation, as required by its compliance procedures (36 CFR Part 600), for any property listed in the National Register affected by a federally assisted project.

The five relocation methods ranged from retaining only the main floor interior of the building and reconstructing it within a nonhistoric building shell to retaining all the original building fabric and machinery. The latter alternative was finally chosen. Eventually the choice of sites was narrowed to two, one of which was intended as a permanent site. The other was a storage site, to be used only if an agreement with the county for the preferred site could not be reached by the scheduled time of the relocation. Studies were also made to identify the obstacles which would be encountered on each route to the two sites.

In July 1976, the Philadelphia District of the Corps of Engineers awarded a $387,000 low-bid contract for all services involved in the relocation of the Wagon Works from its original location to a new site out of the impoundment area of the reservoir. The contract was awarded to the design and construction team of R.S. Cook and Associates, Inc., general contractors and construction managers, Philadelphia; John Milner Associates, preservation architects and planners, West Chester, Pennsylvania; Keast and Hood Company, structural engineers, Philadelphia; and C. Van Howling and Sons, building movers, Wallingford, New Jersey. A prequalifying proposal, submitted prior to the actual bidding, required the preparation of a detailed preliminary analysis and design of the overall project. This proposal had to meet the technical requirements of the Corps, while at the same time preserving the entire building, including the machinery and rural industrial ambience that had been maintained at the Wagon Works virtually without change since before World War I. The disassembly method was left up to the potential bidders, but the Corps directed that it be fully explained as part of the proposal.

The prequalifying proposal also had to contain a plan to relocate the Wagon Works on two possible sites: a temporary, nonreassembly storage site on Corps-owned land, and at the permanent site on Berks County park land at Red Bridge, just west of Reading, Pennsylvania. Subsequent to the submission of the proposals but prior to the bidding, the Corps and Berks County reached an agreement on the permanent Red Bridge site; thus the bidding on the storage site was dropped. The county agreed to provide the land for the relocation of the Wagon Works, with the Corps providing for both the moving and restoration of the buildings. The agreement also stipulated that following restoration, ownership of the relocated Wagon Works would be transferred to Berks County which would then maintain the restored complex and operate it as a museum.

At first it seemed logical to separate the building only along the planes between the several historical additions, but this proved to be impractical because it would have resulted in greater fabric disturbance. The building was carefully separated into four major sections and the appendages divided into several minor parts so that fabric separation was minimized. The usual practice of indiscriminately slicing a structure apart along a single plane with a chain saw was not permitted in this case. Instead, the disassembly plans provided for removing individual pieces of original fabric and specific procedures for cutting or disassembling each affected structural member or joint. (Figure 35 shows the projecting beams.) It would have been easier to butt cut the joints, reconnecting them later with exposed plates and cleats. However, this crude reassembly was not acceptable, because it would have been visible on the exposed interior framing, or "open finish" common to most early frame industrial structures.

Care was taken so that the joints between all disconnected or severed parts came apart horizontally to insure that the sections would separate and rejoin without conflict. Disconnection of joints along the same separation plane was systematically studied to make certain that any member continuous between two adjacent joints was included with

Figure 35: Separation planes

A staggered disconnection of the flooring was adopted in order to camouflage the cuts in the construction after the sections were reassembled. The separation plane for the walls and roof fell along an existing structural division, thus permitting a single straight separation. [Photograph: Courtesy of John Milner Associates]

the same building section. In addition, on the working drawings each structural member was noted with the number of the building section with which the member was to be included as a separation aid (figures 36 and 37). Siding and flooring were removed along the separation planes either to existing joints or new staggered joints to eliminate the reassembled appearance of a line indiscriminately cut through the building. (See staggered floorboards, figure 35) Structural reinforcing, consisting primarily of timber bracing and tie rods, was added throughout the building both to strengthen existing unstable conditions and to provide support along separation planes where the structural system was temporarily disconnected.

Since the main structure had to be separated into parts about 30 feet wide for the 5-mile trip along a two-lane highway and onto the new site one-half mile down a narrow secondary road, it was necessary to adopt a dismantling procedure that would satisfy cost restrictions and yet minimize removal and disturbance of the original fabric. Thus the plan had to establish separation planes that would meet the size limitations and do the least damage. The individual tasks required to stabilize, separate, remove and rejoin or reassemble all building parts, machinery, and the power transmission system were studied in advance, as was the need to support or strengthen these elements during the relocation. The resulting relocation design was presented in explicit working drawings (see figures 36 and 37) and specifications which had been outlined in the prequalifying proposal by the architectural and engineering consultants. Work in this area was facilitated by the existence of the measured drawings and other documentation done by the Historic American Engineering Record (HAER) in 1973, 1974, and 1975. These HAER documents, which will be retained on file in the Library of Congress, include field notes, sheets of plans, sections and elevations, and exterior photographs; also included are many interior photographs taken in 1973–1974, and photocopies of photographs of the building, equipment, and workmen taken at various times during the years of operation of the Gruber Wagon Works.

In addition to the building itself, the machinery and the power generating and transmission system had to be relocated. Wherever possible, these mechanical devices and assemblies were left in place, stabilized as required, and moved along with the building. However, it was necessary to remove the entire main drive shaft and several secondary shafts hanging from the basement ceiling to accommodate the rigging beams. The Otto gasoline engine and several machine tools were also removed separately because they were in the basement or on slabs on grade. In order to control these removals, a complete inventory had to be made of the mechanical system; this premove tagging ensured that each pulley and shaft assembly was returned to its correct location during the reassembly.

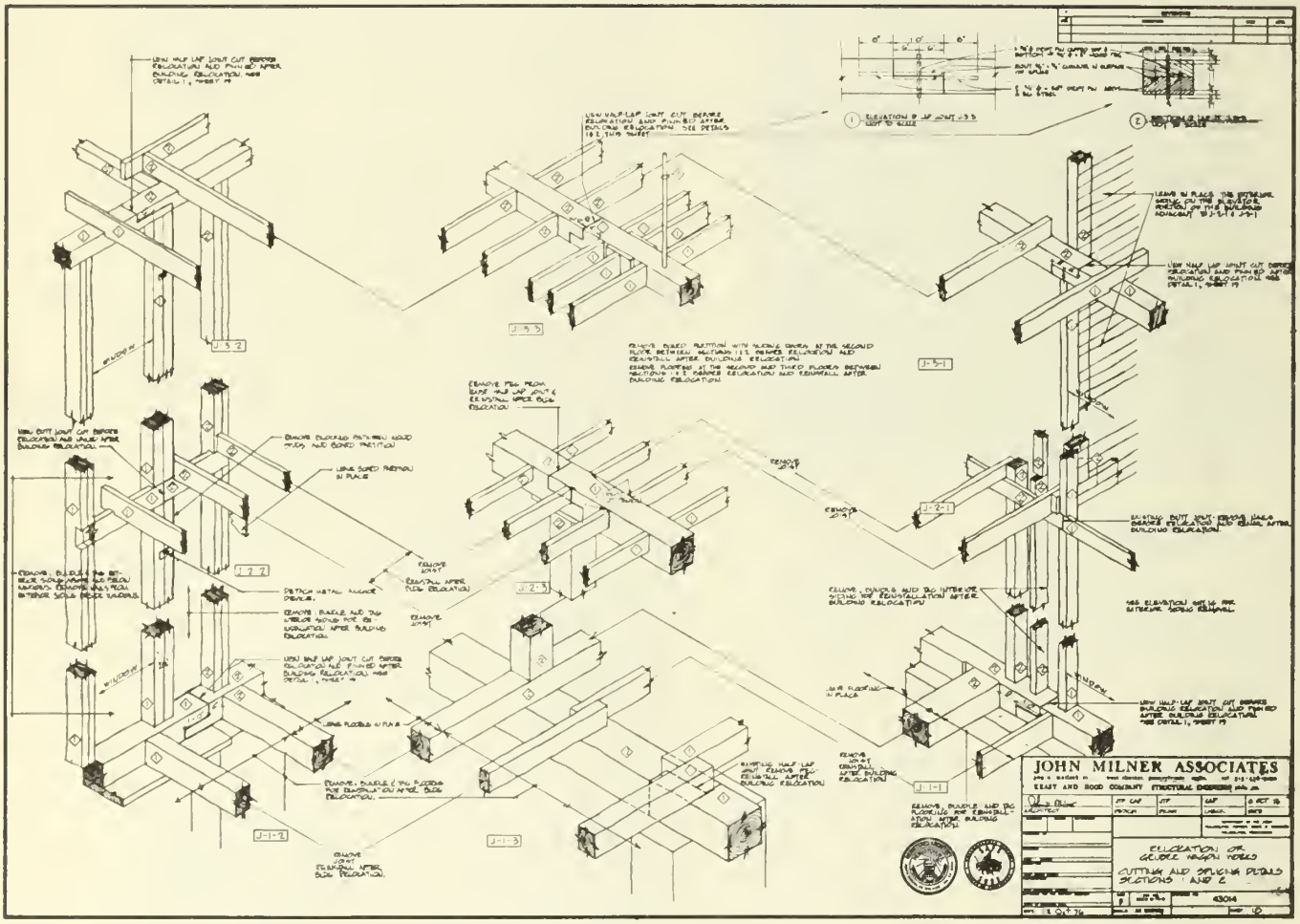


Figure 36: Working drawing, "Cutting and Splicing Details."

Details from sheet 18 of the working drawings are indicative of the meticulous study and thought devoted to the early planning stages of the Gruber Wagon Works relocation project. This drawing showing cutting and splicing details of the structural framework for sections 1 and 2 of the Wagon Works was prepared by John Milner Associates, the architectural firm which supervised the disassembly and move. Note the carefully worded and thorough descriptions supplied on the drawings to ensure that disassembly, removal, storage, and reassembly of the structural members were carried out in a manner that would cause the least harm to the buildings, thus preserving their historical integrity as much as possible. [Photograph: Courtesy of the Philadelphia District, U.S. Army Corps of Engineers]

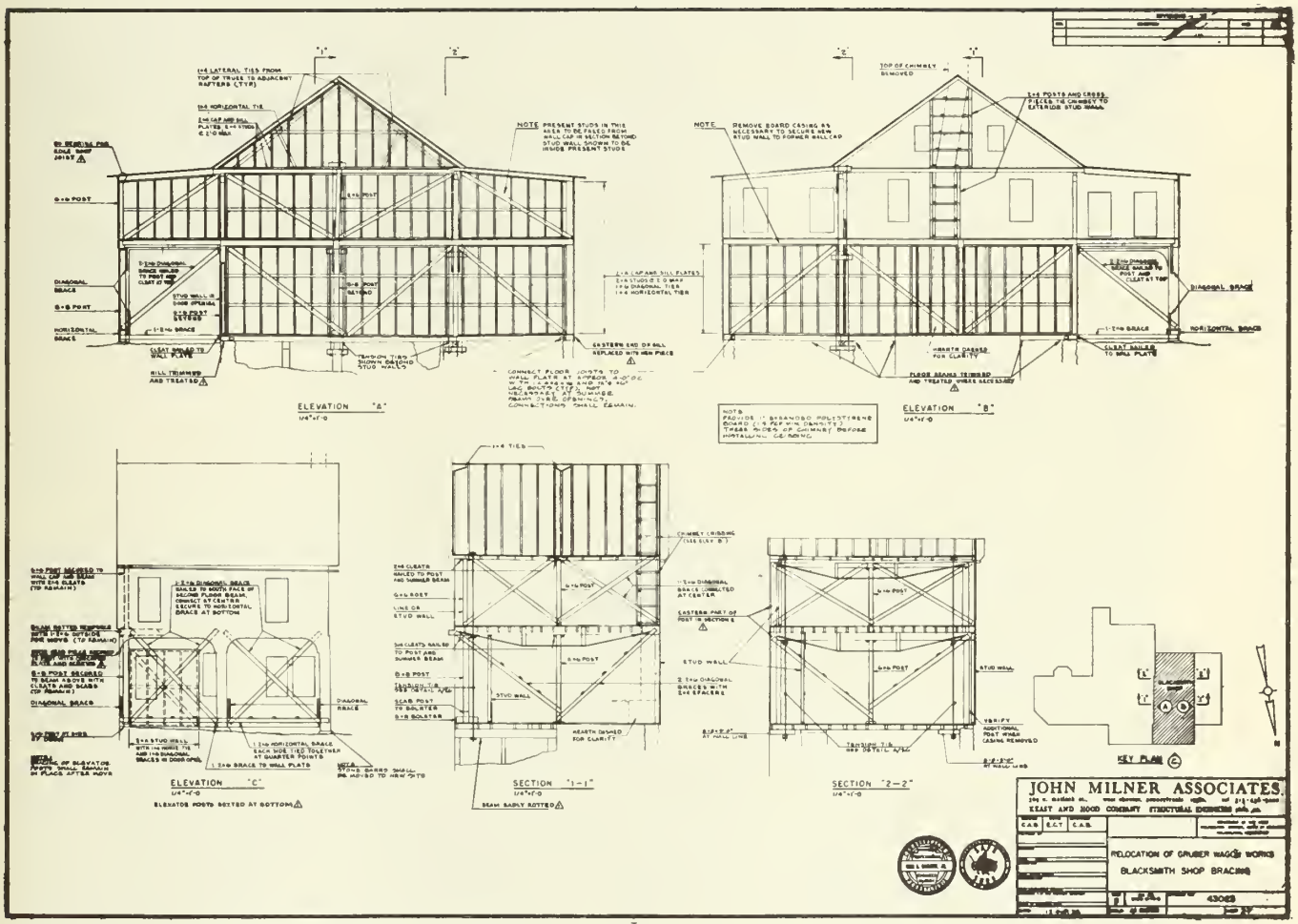


Figure 37: Working drawing, "Blacksmith Shop Bracing."

This sheet of the working drawings was prepared by the structural engineering firm of Keast and Hood to illustrate graphically areas of structural weakness in the various buildings of the Gruber Wagon Works complex, and the way in which these areas should be supported and braced in order to withstand the strain of the move. This working drawing (like Figure 36) indicates the location of badly rotted and decayed wood members, and directs that many of these members be reinforced, replaced, or treated with a preservative before disassembly and the move. [Photograph: Courtesy of the Philadelphia District, U.S. Army Corps of Engineers]

Figure 38: The Gruber Wagon Works and obstacles en route

The largest section and central portion of the Gruber Wagon Works, 26 feet in width by 71 feet in length, was moved on December 8 and 9, 1976. This photograph shows some of the difficulties encountered in moving an unwieldy structure of this size, such as negotiating sharp corners on narrow country roads. Note the extension and cross-arms atop the utility pole to allow for temporary raising of the power lines to permit passage of the structure. The openings left by the removal of roofs and gables have been covered to protect the interior of the structure from the harsh winter weather. [Photograph: Courtesy of John Milner Associates].

Before moving the first of the three largest sections (figure 38), the overhead electrical primaries that crossed the route with less than 40 feet of clearance were temporarily raised. The secondary lines were extended with temporary wire coiled to their poles. The roof and gables of the elevator penthouse of the central section were removed to bring its overall height down to that of the other two large sections. Thus, the cost of relocating the electric primaries was minimized. The temporarily lengthened electric secondaries and telephone cables were then dropped directly on the road ahead of, and crossed by, the moving rigs. At no time was any service interrupted. The cost of utility relocation came out of the original contract sum along with all other costs.

The actual pulling apart and relocation of the various sections followed the aforementioned structural stabilization and structural and mechanical disassembly. Each of the three largest sections of the main building was supported on a cribbing of steel beams and carried on three 8- or 12-wheel dollies. The beams were pushed through holes cut through the foundation—a process known as "needling." The cribbing consisted of stringers placed transversely to the direction of travel and converging girders placed longitudinally, under which the dollies were located in triangular support. Smaller sections of the building were moved on "low-boy" type flat-bed trailers (figure 39).

The three largest sections were taken to the new site in two separate operations. The central and largest section, 26 feet wide by 71 feet long, was moved on December 8 and 9 (see figures 35 and 38), and the other two, 28 feet wide by 35 feet long and 24 feet wide by 43 feet long, in convoy on December 22 and 23 (figure 40). The actual transportation over the chosen 5.5 mile route, although certainly the most dynamic and photogenic portion of the entire operation, was probably also the least novel part of the job. As explained earlier, this procedure has been repeated many times in much the same way and has been practiced at least since the late 18th century in the United States. A 16mm motion picture film, in addition to hundreds of 35mm color slides and black and white photographs, documented the sectioning of the building and the move.

Figure 39: This section of the Gruber Wagon Works, only somewhat wider than a house trailer, was small enough to be transported over the narrow country roads on a "low-boy" flat-bed trailer. [Photograph: Courtesy of John Milner Associates]

Figure 40: Equalizing the towing forces

To balance a building properly during a move, it is often necessary to attach heavy vehicles behind as well as in front of the structure. Pictured here is the largest section of the Gruber Wagon Works on its way to a new site, its weight suitably aligned through careful positioning of two truck tractors in the rear to offset the momentum being created by the two trucks in front pulling the structure. [Photograph: Courtesy John Milner Associates]

The three large, dolly-transported building sections were each moved about 800 yards through a frozen and fortunately level corn field just above the new site (figure 41). This route was used because the trees along the narrow public right-of-way made it impassable at that point. The largest of the three major sections was moved to the new site first because it was the central piece and it was advantageous to reattach the adjacent smaller and lighter sections to it.

As might be expected, the reassembly proceeded in approximately the reverse order of the disassembly. The success of the entire scheme, of course, lay in the reassembly, not in the disassembly or the transportation. After locating the building sections approximately in their final positions by winch and replacing the dollies with timber cribbing, the exact rejoining and leveling was performed with both mechanically and manually-powered hydraulic jacks and manually-operated pulling jacks known as "come alongs."

During reassembly, several badly rotted structural members, principally sill plates, were replaced in locations where it would have been extremely difficult and costly to replace them after the reassembly had been completed. A new foundation was built beneath each section after it was positioned, leveled, and structurally reassembled over new footings. The concrete block foundation consisted of a permanent core and temporary exterior veneer, to be replaced eventually with stone from the original foundation walls. The roof was temporarily sheathed in plywood and roofing felt while awaiting a new slate roof to replace the decayed and discarded original. All machinery and shafting were repositioned, but will not be finally leveled and made operational until restoration of the building fabric is completed.

The restoration of the Gruber Wagon Works on its new site is in progress as of this writing. Only with completion of the restoration, integration of other site improvements planned by Berks County, and the inauguration of the Wagon Works as a museum of rural technology, can the success of the total project be measured and the worth of the relocation be established.

Figure 41: Temporary reinforcement for Gruber Wagon Works move

Dignified though ungainly, on its way to a new home, the largest section of the Gruber Wagon Works is pulled slowly by two trucks followed by two more trucks at the rear to balance and stabilize the weight of the building section. This view also shows some of the temporary internal bracing that was especially designed to stiffen the building where the wings and additions were removed to facilitate the relocation. [Photograph: Courtesy of John Milner Associates]

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